Report

Soil and Groundwater Investigation
Fire Training Center - North Boeing Field
King County Airport
Seattle, Washington

October 26, 1992

Volume I of II

Prepared for

Boeing Corporate Environmental Affairs
Seattle, WA

Prepared by

Landau Associates, Inc.
P.O. Box 1029
Edmonds, WA 98020-9129
(206) 778-0907

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1.0 INTRODUCTION

This report summarizes historical, geological, and chemical data gathered during a soil and groundwater investigation at a former fire training center located at the King County Airport in Seattle, Washington. The purpose of the investigation was to further characterize soil and groundwater quality at and near the former facility. In keeping with accepted terminology, the site will be referred to as the North Boeing Field Fire Training Center (NBF FTC). Previous investigations at the NBF FTC include: 1) a July 1983 study by Shannon & Wilson, Inc.; 2) a May 1984 soil sampling event by Laucks Testing Laboratories, Inc. (Laucks); and 3) a December 1987 soil and groundwater investigation by CH2M Hill Northwest. This report summarizes the previous investigations and presents the results and conclusions of a field program conducted by Landau Associates during July 1992. Laboratory results are contained in Volume II of this report.

2.0 DESCRIPTION OF THE NORTH BOEING FIELD FIRE TRAINING CENTER

The NBF FTC is located approximately 1,000 ft northwest of the north end of the King County Airport main runway. An inactive power plant owned by Seattle City Light is located about 200 ft to the northwest. A vicinity map is presented on Figure 1. The site location relative to surrounding features is shown on Figure 2.

The fire training center consists of a rectangular shaped earthen impoundment measuring approximately 140 ft by 100 ft. The impoundment is divided into two cells by an earthen dike. The larger southern cell is approximately three times the area of the smaller northern cell. The bottom of the cells are at the approximate elevation of surrounding grades and the berms are generally 2-3 ft above grade. Both cells are unpaved and uncovered.

Also present near the impoundment are a storage shed and 500-gal underground storage tank. The tank was used for the storage of jet fuel for the fire training exercises. One other nearby feature includes an approximate ¼-acre geotextile-covered area and drainage ditch.

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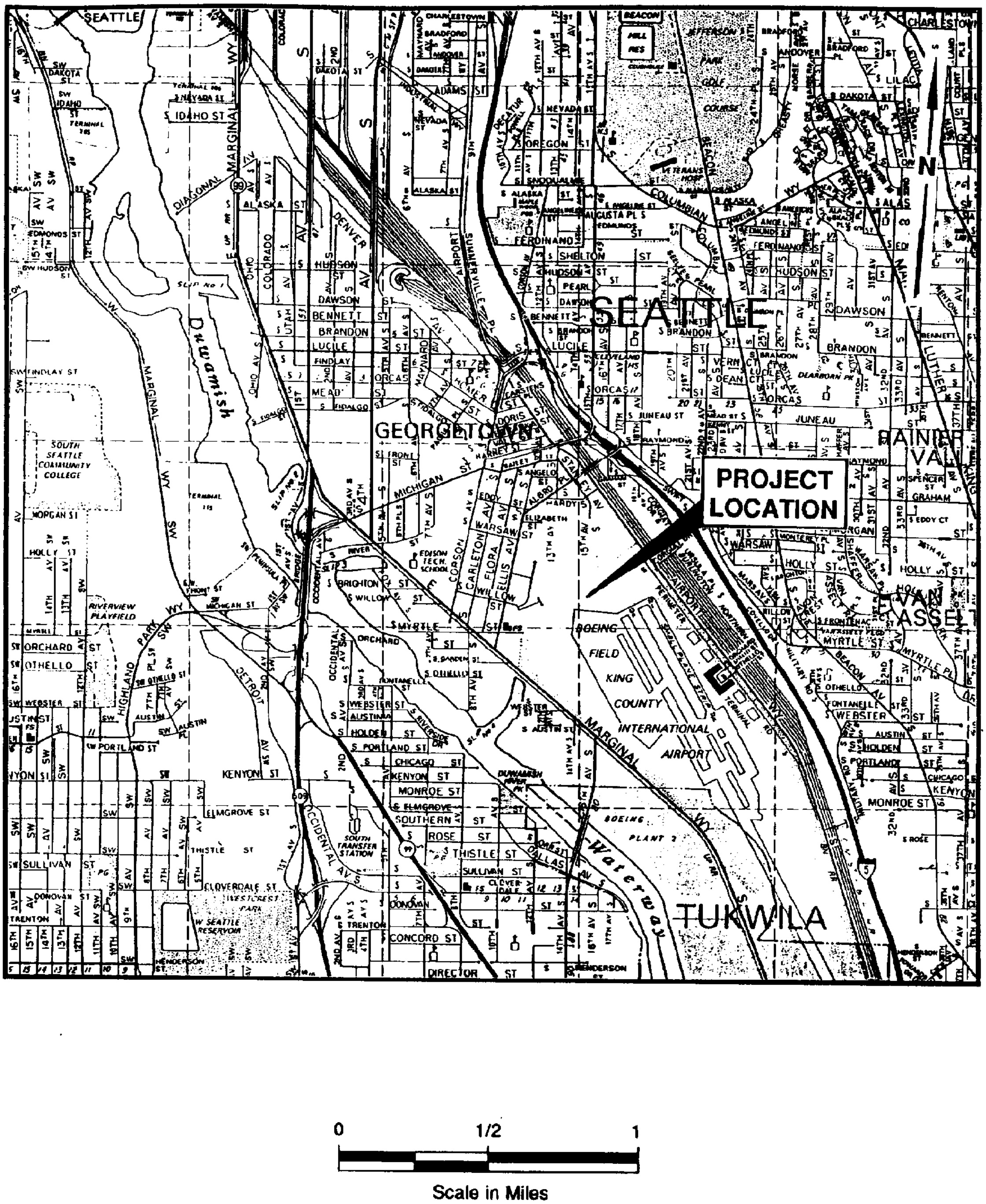

Vicinity Map

Figure 1

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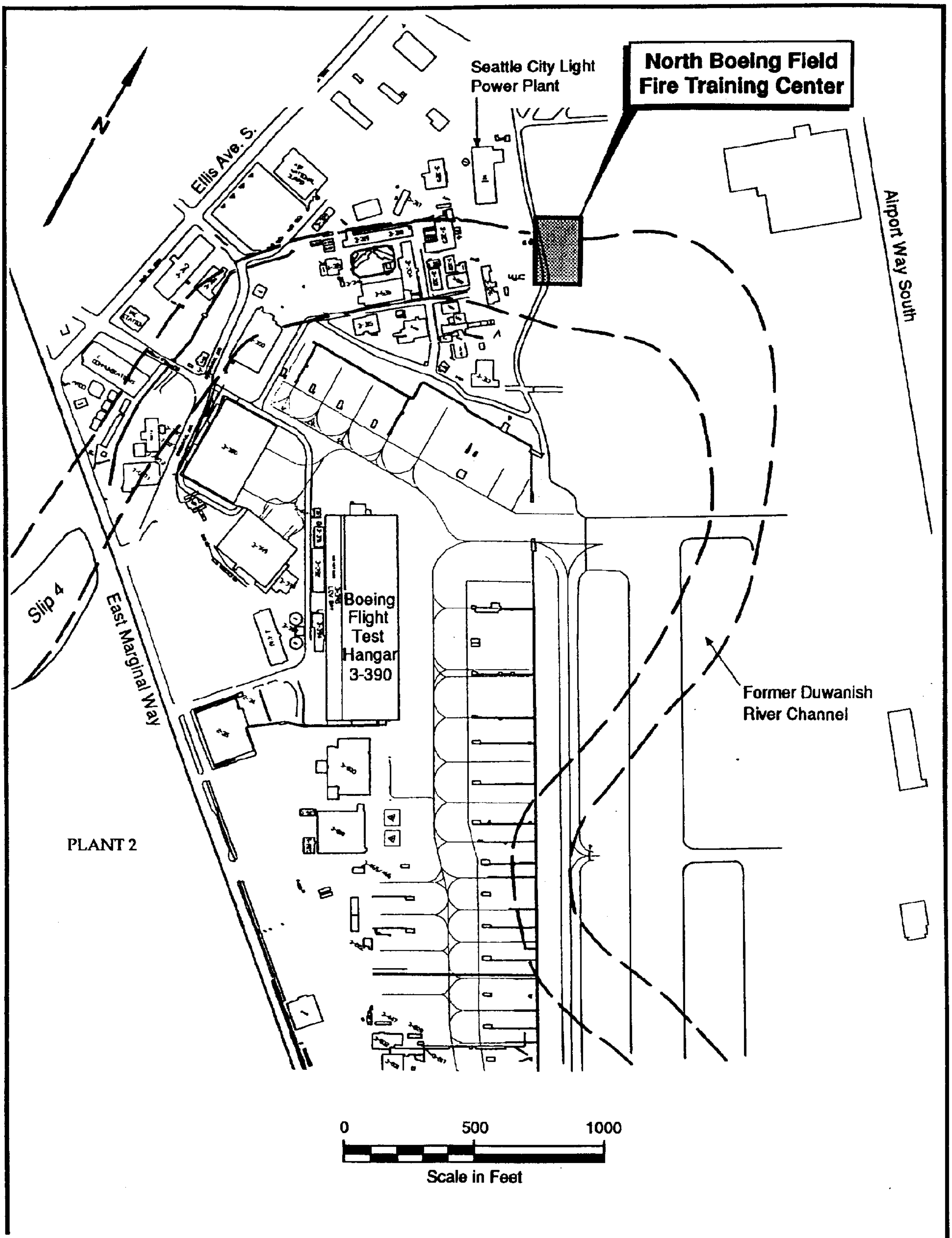


North Boeing Field Training Center
Location Map

Figure 2

Underlying the geotextile are one concrete and one wood catchment basins which were apparently part of a drainage system for the impoundments (Shannon & Wilson 1983; CH2M Hill 1987). These features are shown on the Site Map, Figure 3.

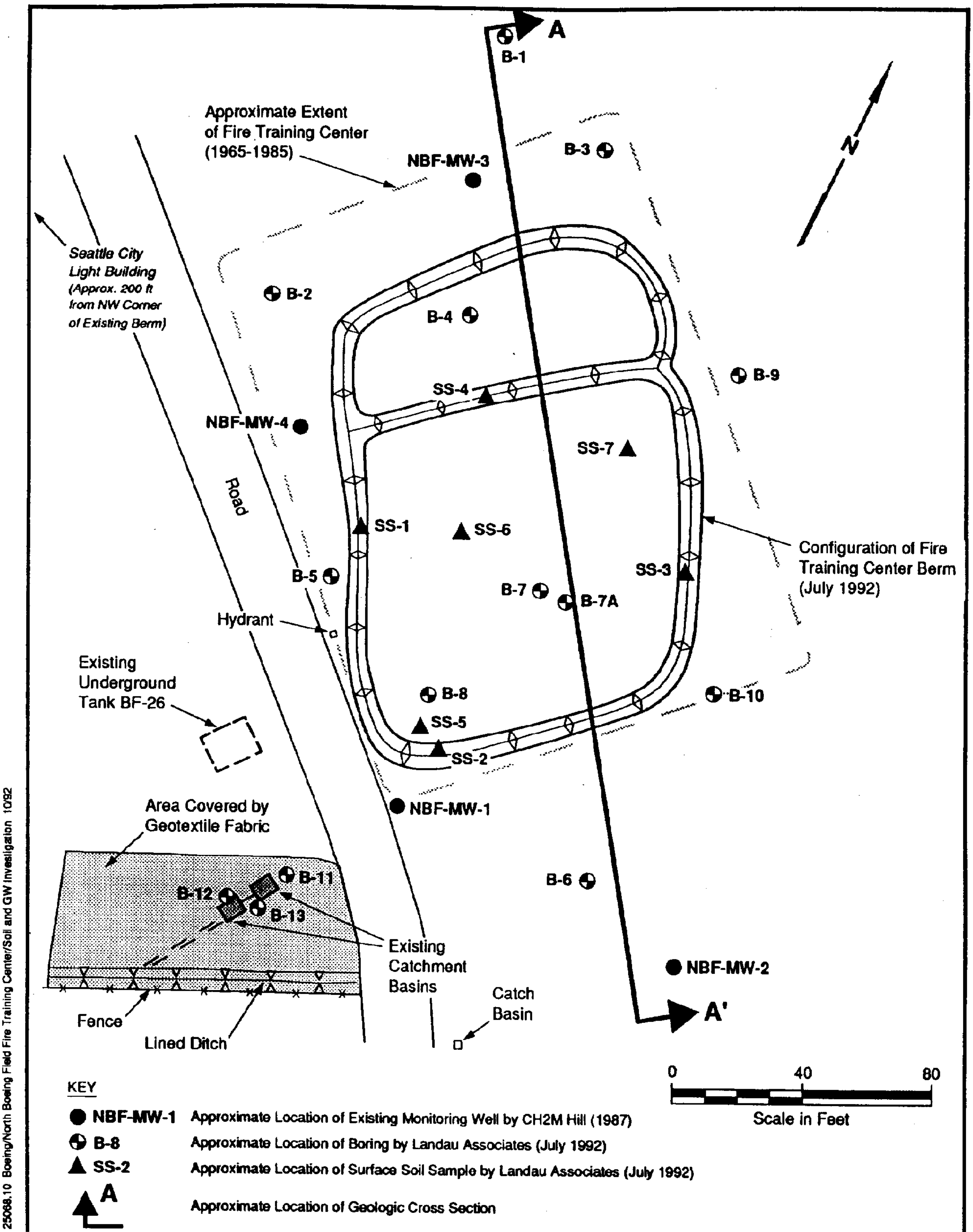
According to informal interviews with King County Airport personnel, the NBF FTC was last used for fire training exercises during the winter of 1991/92. Apparently the fire training exercises were conducted (in the most recent past) by filling the southern cell of the impoundment with water and placing a floating layer of flammable liquid (jet fuel) on top of the ponded water. Gasoline torches were then used to set the liquid aflame and the fire was subsequently extinguished with water and/or foam. Because the predominant wind direction in the area is southwesterly, the fire trucks and personnel usually were staged at the southern end of the impoundment allowing the exercise to be conducted from the upwind direction. The smaller northern cell functioned to retain spill-over generated from the high pressure water hoses used to extinguish the fire.

3.0 HISTORY OF SURROUNDING AREA AND THE FIRE TRAINING CENTER

An historical investigation was performed for the NBF FTC and the immediate vicinity in order to better define past site uses. Information was obtained from the following sources: aerial photographs (Pacific Aerial Surveys 1961; Walker & Associates 1936, 1946, 1956, 1960, 1974, 1980, and 1985; Washington Department of Natural Resources 1965, 1970, and 1978; and H.G. Chickering 1965); topographic maps (U.S. Geological Survey 1908, 1949, 1968, 1973, and 1982); Seattle city atlases (Kroll Map Company 1904, 1920, 1928, and 1950; an unidentified atlas from 1919); fire insurance maps (Sanborn Map Company 1929 and 1949); and Duwamish River surveys (U.S. Army Corps of Engineers 1897 and 1907).

3.1 SURROUNDING AREA

Prior to development, the area surrounding the site consisted of either undeveloped marshlands or pasture. A meander of the Duwamish River passed through part of the current location of the NBF FTC as shown on Figure 2. Significant features at that time included the



Site Map

Figure 3

Grant Street Electric Railway Railroad line, which ran north of the site to Georgetown, and the Columbia & Puget Sound (CPS) and Northern Pacific Railroad (NP) lines located approximately 400 yd northeast of the site.

By 1907, more development of the surrounding area had occurred. Most significant was the establishment of a Seattle Electric Company (SEC) powerhouse to the northwest of the site (the current City Light Building) and its repair shops located to the northeast near the CPS and NP railroad lines. Northeast of the powerhouse was an 824,620-gal concrete fuel oil storage tank. Aerial photographs from 1936 to 1985 show that the tank is mostly belowground, with a portion aboveground and surrounded by an earthen berm. This tank was demolished in 1987.

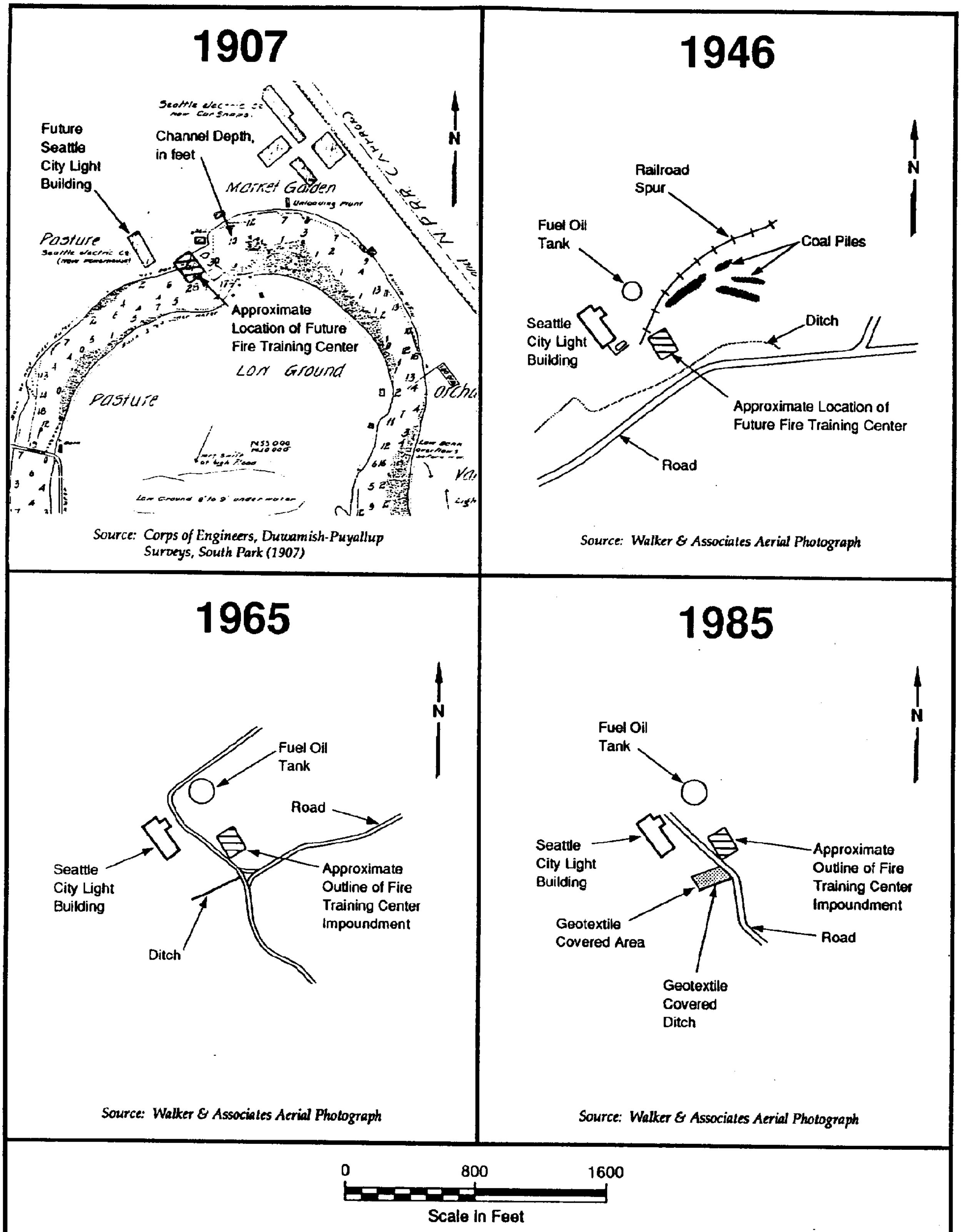
Between 1917 and 1919, the meanders of the Duwamish River were filled in and the Duwamish Waterway was constructed. The western end of the meander near the site was not filled and became the present day Slip No. 4 (Figure 2).

Figure 4 shows four sketches of historical site development. The sketch of 1904 conditions shows the powerhouse and the former meander of the Duwamish River. The numbers along the river refer to channel depth soundings at those points. The 1946 sketch shows the development surrounding the Seattle City Light power plant, including coal piles, and the fuel oil storage tank. Also shown is what appears to be a drainage ditch running east/west just south of the site.

3.2 SITE HISTORY

The only historical information concerning site use prior to construction of the fire training center is limited to inference from aerial photographs taken approximately twice a decade from 1936. Aerial photographs from 1936 and 1945 show a railroad spur track, located very close to the future site location. Apparently, the spur track functioned to serve the power plant, possibly by bringing in shipments of coal.

The earliest indication of site use as a fire training center is evident in a 1965 aerial photograph, which shows vehicles parked in the center of an area of ground disturbance defined by what appear to be berms. The configuration of these berms appears to change through time, as evidenced in the 1970, 1978, and 1980 aerial photographs. In particular, the maximum former



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Historical Sketches of Site Features and Vicinity

Figure 4

extent of the fire training center impoundment, as deduced from aerial photographs, may have extended in the limits shown on Figure 3. The separation of the impoundment into two cells similar to the current configuration is first noticed on the 1985 aerial photograph. The 1985 aerial photograph also shows that the geotextile fabric southwest of the fire training center was in place by that time.

4.0 PREVIOUS INVESTIGATIONS

Shannon & Wilson, Inc. (Shannon & Wilson 1983) was retained by Boeing to drill six soil borings adjacent to the fire training center. According to their report, evidence of petroleum product (namely petroleum odor) was found in three of the six borings. One of these three borings was drilled just outside of the bermed area. The other two borings with petroleum odors were located adjacent to the catchment basins shown on Figure 3. No samples were collected for chemical testing by Shannon & Wilson, Inc.

In 1984, Laucks Testing Laboratories, Inc. (Laucks 1984) sampled surficial soil for Boeing. Samples were collected from eight locations inside the bermed area of the fire training center, two locations in the drainage ditch and one background sample. The samples were analyzed for lead and PCBs. All lead concentrations were between 28 and 360 mg/kg. The PCB concentrations were between 0.05 and 2.5 mg/kg in the bermed area. PCB concentrations in the two ditch samples were 4.7 and 8.9 mg/kg.

In December 1987, CH2M Hill Northwest (CH2M Hill 1987) conducted a soil and groundwater investigation of the NBF FTC. CH2M Hill installed four monitoring wells (designated NBF-MW-1 through NBF-MW-4) at the locations shown on Figure 3. A limited number of subsurface soil samples were collected for laboratory analysis during installation of the monitoring wells. The wells are all screened across the groundwater surface and are between 15 and 17 ft in total depth.

Soil and groundwater samples taken by CH2M Hill were analyzed for volatile and semivolatile organics, pesticides/PCB, and metals. Other than trace concentrations of probable laboratory contaminants, only arsenic was found above method detection limits in the groundwater samples. Arsenic was reported in groundwater from two wells, MW-3 at 5 μg/L and MW-4 at 12 μg/L. Chemicals detected in the soil samples other than those likely related to laboratory contamination include xylene (up to 87 μg/kg), tetrachloroethene (up to 98 μg/kg), toluene (up to 11 μg/kg), 4-methyl-2-pentanone (up to 9 μg/kg), and 2-butanone (up to 67 μg/kg). Data from all three of the previous investigations, including boring/well logs and analytical data summaries are reproduced in Appendix A, and further discussed in Section 8.0.

5.0 FIELD PROGRAM

The field program conducted for this study consisted of drilling and sampling 14 soil borings, collection of 7 surficial soil samples, and collection of groundwater samples from the 4 existing wells. All field work was conducted during July 1992. The purpose of the field program was to collect and analyze samples to further characterize soil and groundwater quality at the site. Figure 3 shows the location of the borings and surficial soil samples and the four CH2M Hill monitoring wells.

Four of the soil borings were drilled inside the impoundment and four were drilled outside the impoundment but inside the possible former limits of previous impoundments. Three soil borings were drilled outside of the estimated limits of the former impoundments, and three were drilled adjacent to the catchment basins. Four surficial soil samples were collected from the impoundment berms and three surficial soil samples were collected from the bottom of the southern cell. Boring logs are presented in Appendix B.

The soil samples were selectively analyzed for a variety of chemical constituents, with an emphasis on total petroleum hydrocarbons, volatile organic compounds and PCBs; and with a lesser emphasis on metals, semivolatile organics, and Skydrol™ (a colorless, odorless series of fire-resistant aircraft hydraulic fluids). Groundwater samples were analyzed for all of the above compounds. The work plan prepared for this study (Landau Associates 1992) describes the sampling activities, laboratory procedures, health and safety plan, and quality assurance program that were followed during the field program. Appendix C describes the specific methodologies employed during the field program.

6.0 GEOLOGY AND HYDROGEOLOGY

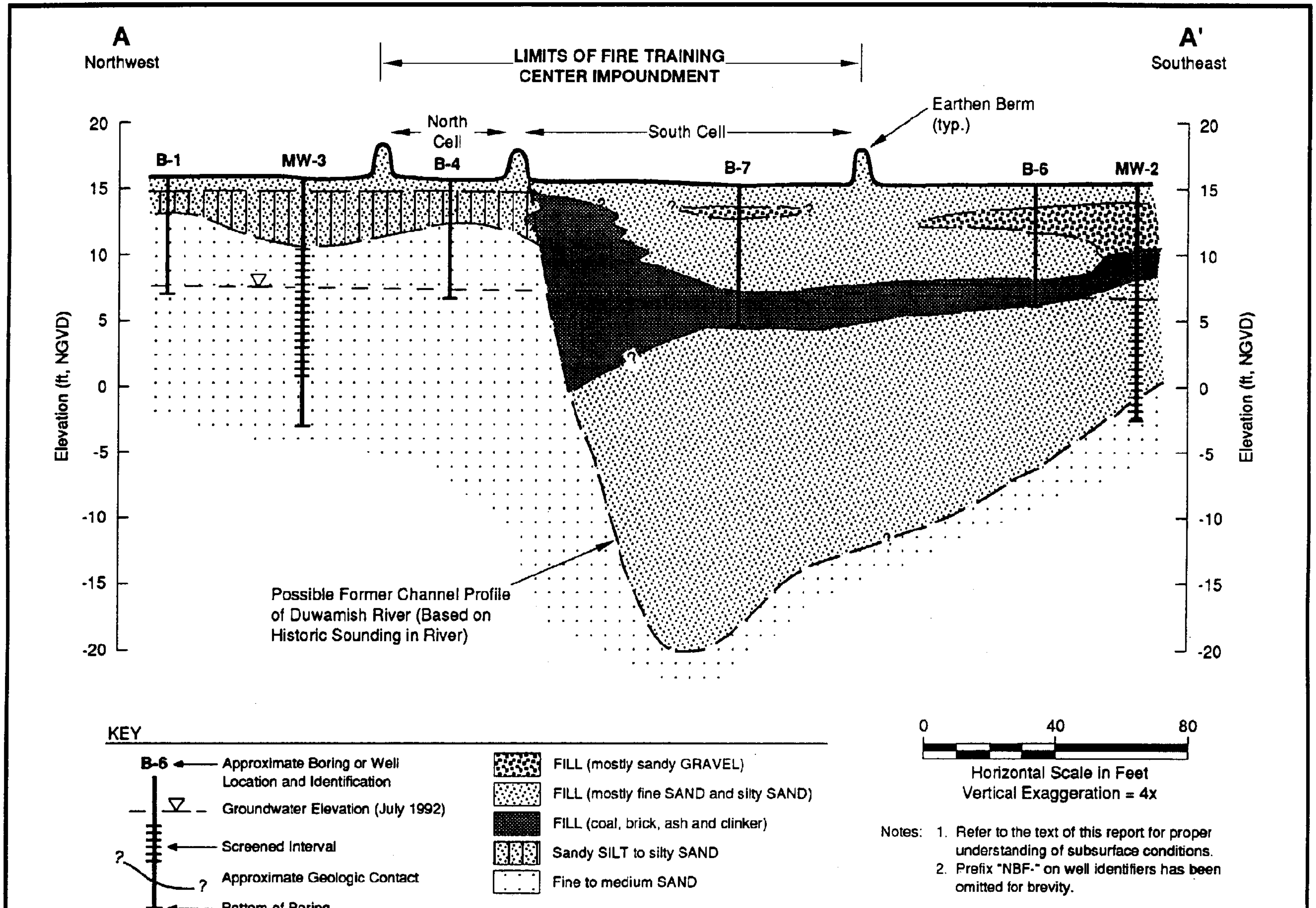
6.1 GEOLOGY

The NBF FTC is located in the Duwamish River Valley. Naturally deposited soil in the valley are comprised of tens of feet of alluvial deposits resting atop marine sediments emplaced during the most recent postglacial period. The surficial geology of the valley changed significantly between 1917 and 1919 when the Duwamish River was channeled to a straighter course. The former meanders of the river, one of which appears to have passed through the southern half of the NBF FTC, were filled mostly with hydraulically dredged sand derived from the channelization project. In addition, much of the valley floor has been raised with more recent fill to accommodate development within the valley.

The geologic deposits of interest at the site include: 1) fill deposits consisting of natural materials, 2) fill deposits consisting primarily of manmade materials, and 3) naturally deposited Duwamish River alluvium. A geologic cross section for the site showing these units is presented on Figure 5. The location of the cross section is shown on Figure 3.

The cross section shows that the geologic deposits underlying the north cell of the impoundment are different from those underlying the south cell. Geologic deposits underlying the north cell consist of a thin (approximately 1 ft) veneer of sandy fill at the surface, underlain by Duwamish River alluvium (mostly sandy silt to fine sand) to at least 20 ft below ground surface. Under the south cell, extending southward to well NBF-MW-2, and at the location of the catchment basins, are surficial fill deposits consisting of a variable thickness of soil (mostly fine sand to silty sand with lesser gravel) underlain by a variable thickness of a granular fill material consisting of coal and brick fragments, ash, and clinker (residue from the combustion of coal). Lying beneath this coal, ash, and clinker fill material is what appears to be hydraulically emplaced fill (mostly fine sand with a trace of gravel, to a possible depth of up to 35 ft in the former river channel). No specific time periods can be assigned to these episodes of filling because of the lack of documentation.

A possible channel profile of the meander is shown on the cross section. The profile was obtained from the 1904 Army Corps of Engineers survey showing depth soundings of the former channel at the location of the fire training center (see 1904 sketch, Figure 4), which indicates the former meander was as much as 35 ft deep in that location.



Geologic Cross Section A-A'

Figure 5

6.2 HYDROGEOLOGY

Regional studies (Landau Associates 1988) indicate a relatively flat groundwater gradient across the North Boeing Field/King County Airport facilities, with a dominantly westward gradient towards the Duwamish Waterway.

Figure 6 shows estimated groundwater elevation contours at the site based on July 1992 data. Groundwater elevations taken in the four preexisting monitoring wells indicate a slightly anomalous groundwater gradient, as compared to the regional gradient. A possible explanation is that filling of the meander may have affected local groundwater flow, caused by the relatively higher hydraulic conductivity of the fill material deposited in the meander as compared to the surrounding native deposits. The groundwater gradient calculated from the July 1992 data is 0.008, or about 40 ft/mi.

7.0 SITE SCREENING LEVELS

In order to identify the compounds of concern (indicator compounds), a screening process was established which eliminated those detected compounds which pose little threat to human health and/or the environment. Washington State's Model Toxics Control Act (MTCA) cleanup regulation (Ecology 1991a) was used as the basis for our evaluation. The specific screening analysis used in our evaluation is consistent with Washington State Department of Ecology (Ecology) guidance (1991b) for selecting indicator compounds, which is as follows:

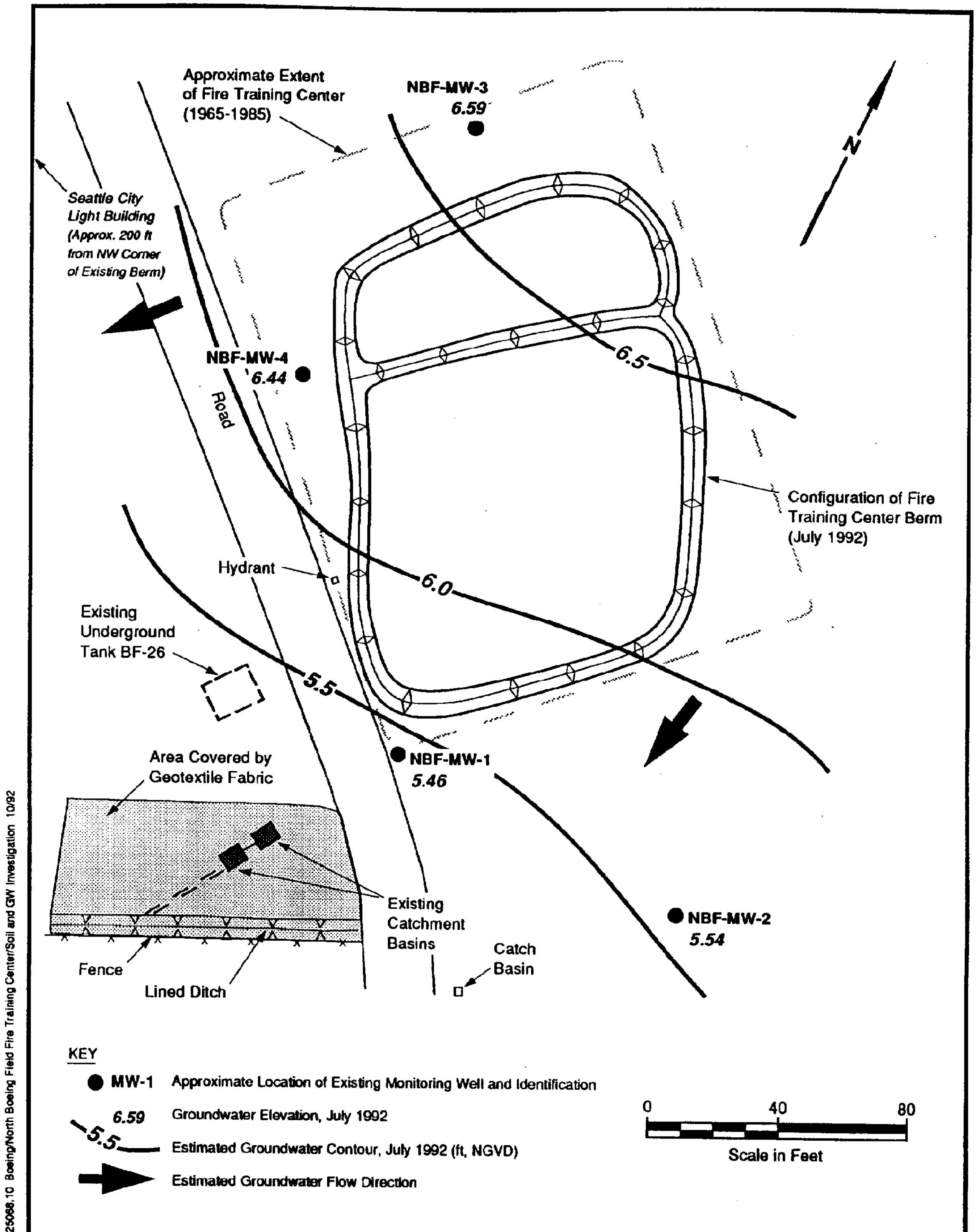
1. "Compare an upper bound concentration of an environmental contaminant to the cleanup level for that medium..."
2. "Substances which do not exceed the cleanup level in a single medium are removed from further consideration."

The rationale upon which our conclusions are based are summarized below:

1. SITE CLASSIFICATION

The NBF FTC is considered an industrial site under MTCA because of the following:

- The site and adjacent properties are zoned for general industrial use.



Estimated Groundwater Contours, July 1992

Figure 6

- The site and adjacent properties are currently used for industrial purposes and have a history of industrial use.
- The site is expected to be used for industrial purposes in the foreseeable future.
- The access to the site is restricted and not available for general public use.

2. SOIL

Where possible, compounds detected in soil at the site were evaluated using Method A tables for industrial sites (WAC 173-340-745). For detected compounds which are not listed on Method A tables, Method C cleanup levels for industrial sites were used. Specific Method C values for compounds detected at the site were obtained from tables provided by Ecology (1992).

For those compounds detected in soil for which no toxicological data is available to calculate Method C cleanup levels, and are also not listed in the Method A table, the following approach was used:

- If the concentration of the compound detected was well below human health-based cleanup levels for related compounds, it was not evaluated further [for example, cleanup levels calculated for specific polynuclear aromatic hydrocarbons (PAH) were used to evaluate similar PAH compounds which lacked toxicological data].
- If the compound detected was not a member of a class of related compounds with available toxicological data, it was evaluated individually. The only compound that qualified for this type of examination was Skydrol™. Development of the screening levels for Skydrol™ is presented in Appendix D.

3. GROUNDWATER

The screening levels used to evaluate compounds detected in groundwater were: 1) the MTCA Method A cleanup levels for groundwater and 2) the screening level for Skydrol™ in groundwater, as described in Appendix D.

8.0 SOIL AND GROUNDWATER QUALITY

The analytical results of soil and groundwater samples are summarized in this section, along with relevant field observations. The concentrations of detected compounds are then compared to site screening levels to identify indicator compounds at the site.

Soil quality data are summarized in Tables 1 through 6, groundwater quality data in Table 7. Tables 1 through 7 can be found following the text of the report. The laboratory reports are presented in Appendix E, Volume II.

8.1 SOIL QUALITY

8.1.1 Total Petroleum Hydrocarbons (TPH)

During the July 1992 field program, field observations (sheen, odor, photoionization detector readings) of petroleum hydrocarbons were made. Positive indications of petroleum hydrocarbons were noted while collecting surface soil samples from the bottom of the southern cell of the impoundment, and in soil samples from Borings B-4, B-7/7A, B-11, B-12, and B-13. Also, liquid petroleum hydrocarbons were observed in the bottom of the northernmost concrete catchment basin.

Field observations indicate that petroleum hydrocarbons diminish with depth in the borings drilled within the impoundment. Conversely, petroleum indications were only apparent in samples from near the groundwater surface in borings drilled adjacent to the catchment basins. No field indications of petroleum hydrocarbons were observed in surface samples from the impoundment berms or in samples from borings drilled outside the impoundment (except at the catchment basins borings).

For soil samples submitted to the laboratory, total petroleum hydrocarbon (TPH) was detected in both surface and subsurface soil samples at concentrations above the Method A cleanup level of 200 mg/kg (the cleanup level for middle distillate range petroleum hydrocarbons). The laboratory was generally able to fingerprint the petroleum hydrocarbons as similar to JP-5, a diesel range petroleum distillate. This is consistent with past use of jet fuel for fire training exercises.

Laboratory analysis of surficial soil samples from the impoundment berms (SS-1 through SS-4) contained variable concentrations of TPH. Two of the samples (SS-1 and SS-4) had TPH concentrations at slightly above the 200 mg/kg cleanup level (330 mg/kg and 350 mg/kg, respectively) and two samples [SS-2 at 53 mg/kg and SS-3 at nondetect (ND) levels] were well below this screening level. The TPH concentrations in surficial soil samples taken from the bottom of the south cell (SS-5 through SS-7) had concentrations ranging from 1,200 to 3,100 mg/kg.

For soil borings drilled within the impoundment, TPH concentrations appear to be present throughout the Vadose zone at Boring B4 (the north cell) and appear to taper off in a wedge-shaped configuration thinning upward toward the south end of the south cell. With the exception of sample B3 (0.0-1.0) from Boring 3 (260 mg/kg), all samples from borings drilled outside of the impoundment had TPH concentrations below 200 mg/kg. The estimated horizontal distribution of TPH in soil above the 200 mg/kg screening level is shown on Figure 7. A cross sectional view of anticipated TPH distribution is shown on Figure 8.

Concentrations of petroleum hydrocarbons ranging from 8,800 to 25,000 mg/kg were detected in all samples from near the groundwater surface in the borings drilled adjacent to the catchment basins. This is consistent with the field observations of strong petroleum odors in those samples.

Based on the occurrence of TPH in soil samples above the screening level, and on field observation of hydrocarbons, TPH has been identified as an indicator compound at the site.

8.1.2 Polychlorinated Biphenyls (PCBs)

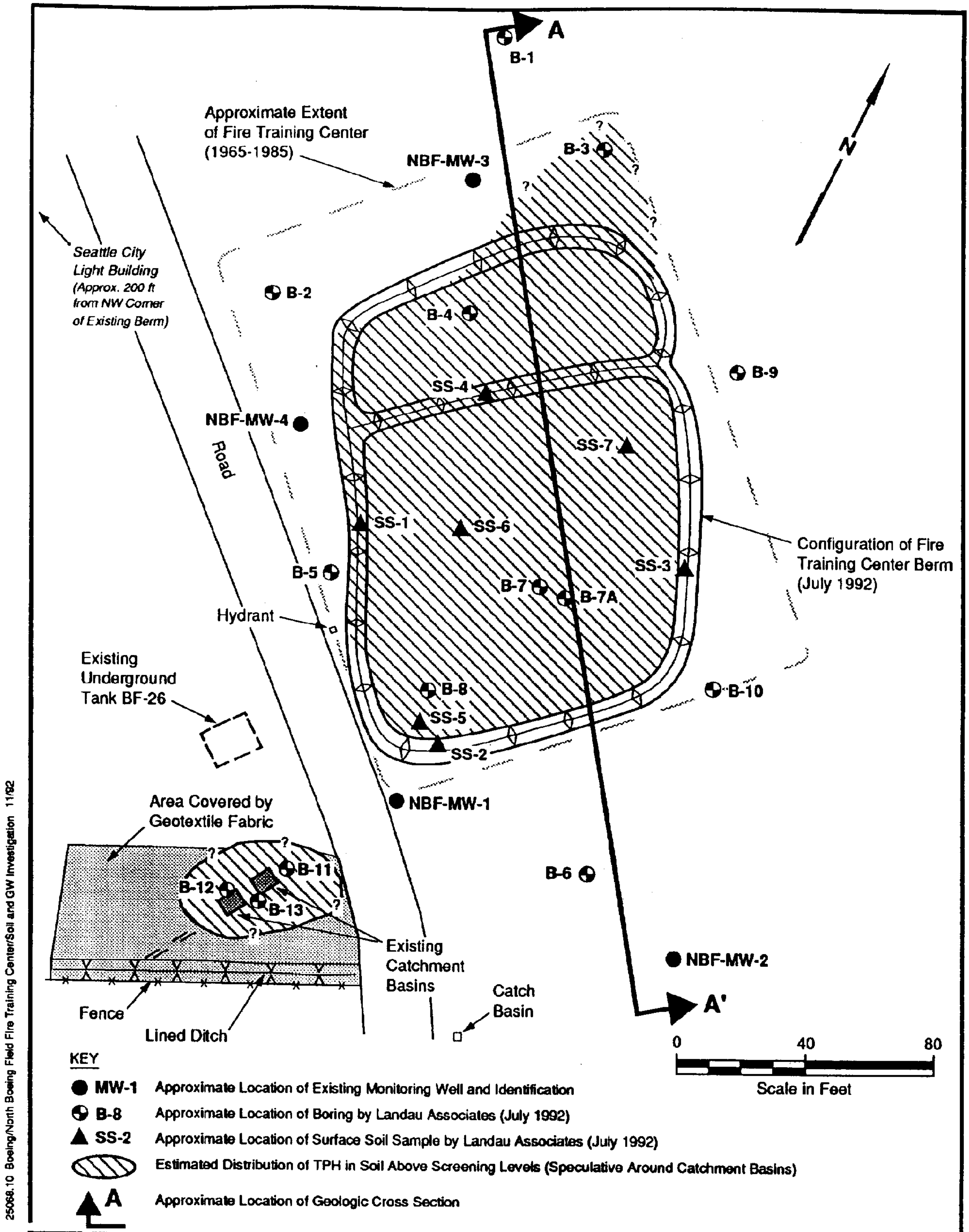
PCBs were reported in 6 of the 24 subsurface soil boring samples and in all 7 of the surface soil samples. Concentrations, however, were generally close to the detection limit of 0.32-0.34 mg/kg for total PCBs.

The highest concentration was in surface sample SS-4 (1.66 mg/kg), which is below the MTCA Method A cleanup level of 10 mg/kg for industrial sites. These analytical results are consistent with the Laucks' 1983 report.

8.1.3 Volatile Organics

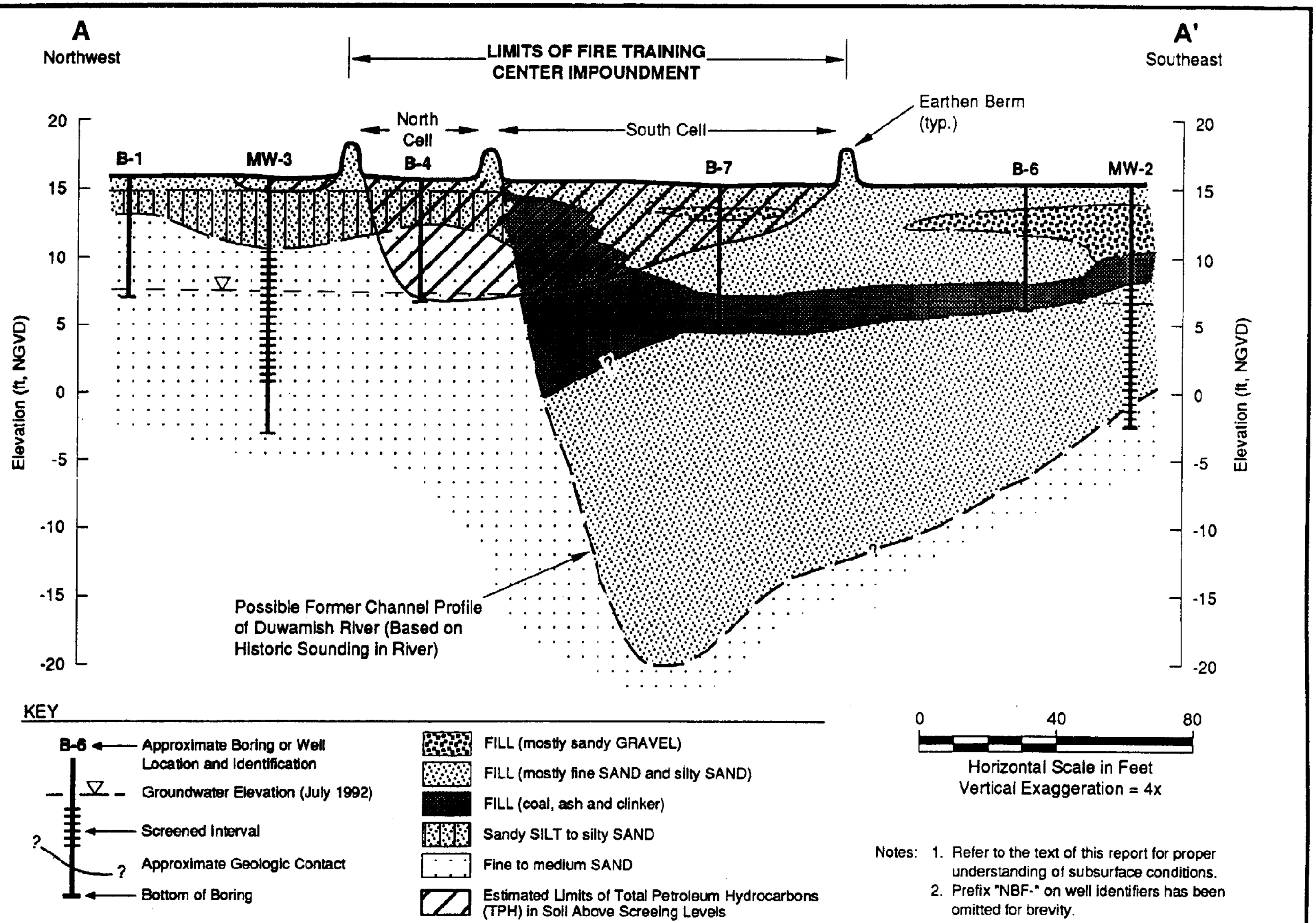
The only volatile organic compounds detected in surface soil samples were trace amounts of common laboratory contaminants, and xylene and toluene. The concentration of xylene in surface sample SS-5 (21 mg/kg) slightly exceeds the MTCA Method A cleanup level of 20 mg/kg. The concentration of toluene (up to 3.5 mg/kg) was well below the Method A cleanup level of 40 mg/kg.

Volatile organic compounds were, with two exceptions, not detected in soil boring samples [except for trace amounts of common laboratory contaminants and low levels of toluene (ND to 0.009 mg/kg)]. One exception to this is in sample B7A (3.0-4.0). Twelve volatile organic compounds were detected in this sample at levels from 0.071 to 0.97 mg/kg. The second exception was the 2-butanone reported in sample B11 (7.0-7.5) at 0.99 mg/kg. Both of these samples also contained concentrations of TPH above the 200 mg/kg screening level.



Plan View Showing Estimated Horizontal Distribution of TPH in Soil Above Screening Level

Figure 7



Notes: 1. Refer to the text of this report for proper understanding of subsurface conditions.
2. Prefix "NBF-" on well identifiers has been omitted for brevity.

Cross Section Showing Estimated Vertical Distribution of TPH in Soil Above Screeing Levels

Figure 8

Both Method A and C cleanup levels were used to evaluate the volatile organic compounds detected. The cleanup levels for all 12 organic compounds were between 2 and 4 orders of magnitude higher than the highest concentration reported in the samples. The volatile organic data from the CH2M Hill report is relatively consistent with the current data. Xylene, toluene, and 2-butanone were detected by CH2M Hill at concentrations within one order of magnitude of the concentrations reported herein. CH2M Hill also reported detections of tetrachloroethene and 4-methyl-2-pentanone, which were not detected during this study. Due to their limited distribution and low concentrations, volatile organics are not considered indicator compounds at this time.

8.1.4 Semivolatile Organic Compounds (PAH)

Twenty-three semivolatile organic compounds were identified in surface and subsurface samples. The widest variety and highest concentrations of these compounds were reported in samples which also had concentrations of TPH above the 200 mg/kg screening level. Most of the semivolatile organic compounds detected belong to the PAH class, which occur in diesel-range and heavier petroleum distillates, and are commonly produced by the combustion of hydrocarbons.

The sample with the highest total concentration of carcinogenic PAH was SS-5, which at 2 mg/kg is well below the Method A cleanup level of 20 mg/kg for total carcinogenic PAH. All of the other noncarcinogenic PAH or miscellaneous semivolatile compounds detected were at concentrations that ranged from 2 to 7 orders of magnitude lower than the corresponding MTCA Method C cleanup level for those or related compounds. Based on these findings, PAH are not considered indicator compounds.

8.1.5 Metals

All of the eight metals analyzed for were detected at least once. The reported concentrations are typical for soil in an urban environment and the concentrations for arsenic, cadmium, chromium, lead, and mercury were all well below MTCA Method A cleanup levels. Zinc, copper, and beryllium concentrations were well below the Method C cleanup levels. Based on these findings, metals are not considered indicator compounds.

8.1.6 Skydrol™

At the present time, there are no State or Federal Standards which specifically address Skydrol™; also Skydrol™ is a blend of several compounds and is, or has been, produced by several manufacturers. This complicates the evaluation of Skydrol™ with regard to regulatory criterion. The approach taken to assess Skydrol™ for this study is described in Appendix D.

Once a Skydrol™ standard was obtained, the laboratory was able to accurately analyze for four of the major constituents of Skydrol™. These are tributyl phosphate, dibutyl phenol phosphate, butyl diphenyl phosphate, and triphenyl phosphate. One or more of these four individual constituents were detected in eight of the ten subsurface soil samples tested.

According to the manufacturer's material safety data sheet for Skydrol™, tributyl phosphate is the primary active ingredient. Tributyl phosphate was the individual compound detected most frequently and in the highest concentrations, followed by dibutyl phenol phosphate and butyl diphenyl phosphate. Triphenyl phosphate was not detected in any of the samples tested.

The soil screening level of 60 mg/kg was exceeded in two of the ten samples tested. Both samples were from B11 (4.0-4.5 ft at 114 mg/kg and 5.5-6.5 at 150 mg/kg) where concentrations of TPH were indicated either by field observations or laboratory analysis. The occurrence and concentrations of these four compounds above the calculated screening level designates Skydrol™ as a possible indicator compound in site soil.

8.2 GROUNDWATER QUALITY

Table 7 summarizes the results of groundwater quality testing. No TPH, PCBs, or volatile organic compounds were detected. Several metals were detected, but at concentrations well below cleanup levels, except arsenic which was detected at 9 μg/L in Well MW-3 and at 11 μg/L in Well MW-4. The MTCA Method A cleanup level for arsenic is 5 μg/L.

Well NBF-MW-3 is located upgradient from the NBF FTC. Well NBF-MW-4 is cross gradient to the north cell of the impoundment. Based on the low concentrations of arsenic detected, and the pattern of distribution, the occurrence of arsenic above cleanup levels appear to be more reflective of natural conditions, or of background concentrations in an industrialized area, than attributable to a release from the site.

Very low concentrations of two semivolatile organic compounds were reported in three wells. These organic compounds are both phthalates-class compounds and are very common laboratory or field contaminants.

Two components of Skydrol™, tributyl phosphate (at 26 µg/L) and dibutyl phenyl phosphate (at 4 µg/L) were detected in Well MW-4. The screening level for Skydrol™ in groundwater of 600 µg/L is explained in Appendix D (reported as the sum of four components). This screening level was not exceeded.

9.0 SUMMARY AND CONCLUSIONS

The primary findings of this investigation are summarized by major topic below:

SITE HISTORY

- A non-operating power plant, now owned by Seattle City Light, is located about 200 ft northwest of the site. The power plant was established in the 1890s and apparently used both coal and fuel oil.
- Development of the site into a fire training center appears to have occurred between 1960 and 1965. The extent of the impoundment defining the site appears to have changed slightly through time.

GEOLOGY AND HYDROGEOLOGY

- The shallow geologic deposits underlying the north cell of the impoundment are distinctly different than those underlying the south cell. The north cell appears to be underlain mainly with Duwamish River alluvium. The south cell and catchment basins appear to be underlain with a variable thickness of fill material. Some of the fill is comprised of coal and brick fragments, ash, and clinker which may have originated as waste material from the nearby power plant.
- A filled meander of the Duwamish River appears to pass under the southern portion of the former NBF FTC.
- Groundwater occurs under the site at shallow depth in apparently unconfined conditions at a gradient of about 0.008 (40 ft/mi) to the south.

TOTAL PETROLEUM HYDROCARBONS (TPH)

- Laboratory samples analyzed for TPH were quantified against a JP-5 standard (JP-5 is Air Force carrier-grade kerosene). Positive identifications were made using this standard. Jet A, as straight-cut kerosene, is the most common grade of commercial fuel which falls into this fuel range, and is known to be used extensively at the airport. Based on the above, it is likely that TPH, reported as JP-5, represents Jet A fuel.

- Figures 7 and 8 show the estimated horizontal and vertical distribution of TPH in soil above screening levels. Assuming that the distribution shown on Figures 7 and 8 represents approximate site conditions, the in-place volume of soil containing TPH above the screening level under and immediately outside the impoundment is estimated at less than 3,500 yd^3.
- An in-place volume of soil containing TPH above the screening level near the catchment basins cannot be estimated at this time.
- TPH was not detected in appreciable concentrations in borings drilled outside the current impoundment (except at the catchment basins). This contrasts with Shannon & Wilson (1983), which reports field observations of petroleum in a boring drilled just outside of the southwestern edge of the impoundment. This discrepancy may be due to past configurations of the impoundment or, alternatively, may indicate a localized area of TPH in soil extending outside of the current impoundment.
- TPH was not detected in groundwater from any of the four existing monitoring wells.

POLYCHLORINATED BIPHENYLS (PCBs)

- During this investigation, PCBs were only detected above method detection limits within the upper 1 ft of soil. The maximum concentrations reported in this and previous investigations are well below the screening level of 10 mg/kg. No PCBs were detected in groundwater, and the risk to groundwater from PCBs in site soil is considered low because of the relatively insoluble nature of PCBs.

VOLATILE ORGANIC COMPOUNDS

- Based on the analytical data generated by this field program, and during previous investigations, soil in the unsaturated zone contains, in places, several volatile organic compounds. A comparison of the concentrations to screening levels (based on protection of human health) indicates that concentrations are well below the selected screening levels.
- The occurrence of volatile organic compounds in soil appears to be restricted to samples which also contain TPH. Therefore, if corrective action is taken at the site to remediate TPH, the volatile organic compounds would also likely be remediated.
- No volatile organic compounds were detected in groundwater samples collected in 1987 or 1992.

SEMIVOLATILE ORGANIC COMPOUNDS

- None of the semivolatile compounds in soil were detected at concentrations above screening levels.
- The semivolatile compounds that were detected occur primarily in samples containing TPH. Therefore, corrective action at the site for TPH would also likely remediate soil containing the semivolatile compounds.
- Except for trace amounts of two common laboratory contaminants, no semivolatile compounds were detected in the groundwater samples taken in 1987 or 1992.

METALS

- The only detection of metals above screening levels in soil or groundwater occurred in groundwater from two wells. Arsenic was detected in Wells NBF-MW-3 and NBF-MW-4 at concentrations slightly above the screening level. However, the presence of arsenic does not appear to be related to operation of the NBF FTC.

SKYDROL™

- Two soil samples contained components of Skydrol™ above the selected screening level. These compounds, therefore, may be indicator compounds for the site. However, because the highest concentrations of these compounds occurred in samples also containing TPH, it is probable that corrective action for TPH would also remediate soil containing the primary constituents of Skydrol™.
- Constituents of Skydrol™ were only detected in one well (MW-4), but at concentrations well below the selected screening level.

SOURCES

- The source of TPH and other compounds in site soil under the impoundment may be reasonably attributed to the use of jet fuel and other flammable/combustible agents. The source of these compounds in subsurface samples near the catchment basins may also be reasonably attributed to activities at the NBF FTC, assuming that the catchment basins were at one time connected to the impoundments.
- No PCB source has been positively identified.

10.0 REFERENCES

CH2M Hill Northwest. 1987. "*Soil and Groundwater Investigation, North Boeing Field Fire Drill Pit.*" Report to the Boeing Commercial Airplane Company, Renton Division-Environmental Engineering. December 1987.

Ecology. 1991a. Model Toxics Control Act Regulation, Chapter 173-340 WAC, Effective February 28, 1991.

Ecology. 1991b. Personal Communication (memorandum regarding selection of indicator hazardous substances.) L. Kissinger, Washington State Department of Ecology, Olympia, Washington. November 1991.

Ecology. 1992. Model Toxics Control Act Human Health Risk Based Method C Formula Value, Washington State Department of Ecology, Toxics Cleanup Program. January 2, 1992, Draft Version.

Landau Associates, Inc. 1988. Preliminary Summary of Soil and Groundwater Information, North Boeing Field Facility, Seattle, Washington. Prepared for Boeing Commercial Airplanes. March.

Landau Associates, Inc. 1992. Work Plan: Site Characterization Study, North Boeing Field Fire Training Center, King County Airport, Seattle, Washington. Report prepared for Boeing Environmental Affairs. March 29, 1992

Laucks Testing Laboratories, Inc. 1984. Laboratory Report No. 84718 to the Boeing Company, attention Mr. Kirk Thompson.

Shannon & Wilson. 1983. "*Subsurface Investigation of Petroleum Product Occurrence, North Boeing Field Practice Pit.*" Letter report to the Boeing Company, attention Mr. Ed Loughrey. July 12, 1983.

TABLE 1
NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
TOTAL PETROLEUM HYDROCARBONS
(mg/kg)

Sample ID	TPH (Gas Range)	TPH (Diesel Range)	
Surface samples:			
SS-1	10 U	330	
SS-2	10 U	53	
SS-3	10 U	10 U	
SS-4	10 U	350	(JP-5) (1)
SS-5	10 U	1700	(JP-5)
SS-6	10 U	3100	(JP-5)
SS-7	10 U	1800	

Sample ID	TPH (Gas Range)	TPH (Diesel Range)	
Sub-surface samples:			
B1 (0.5-1.0)	10 U	14	
B1 (4.0-4.5)	10 U	10 U	
B2 (0.5-1.0)	10 U	90	
B2 (7.0-7.5)	10 U	10 U	
B3 (0.0-1.0)	15	260	
B3 (7.5-8.5)	10 U	10 U	
B4 (0.5-1.0)	10 U	940	(JP-5)
B4 (2.5-3.0)	500 U	13000	(JP-5)
B4 (4.0-4.5)	100 U	4900	(JP-5)
B4 (6.0)	100 U	2400	(JP-5)
B4 (7.0)	10 U	770	(JP-5)
B4 (8.0-9.0)	10 U	1800	(JP-5)
B5 (1.5-3.0)	10 U	13	(JP-5)
B5 (7.0-7.5)	10 U	10 U	
B6 (2.5-3.0)	10 U	10 U	
B6 (8.5-9.0)	10 U	10 U	
B7 (1.0-1.5)	10 U	270	(JP-5)
B7 (1.5-2.0)	10 U	1200	(JP-5)
B7A (3.0-4.0)	10 U	1800	(JP-5)
B7A (4.5-5.0)	10 U	1100	(JP-5)
B7A (5.5-6.0)	10 U	10 U	
B7A (6.5)	10 U	10 U	
B7A (10.0-10.5)	10 U	33	
B8 (1.5-2.0)	10 U	12	
B8 (6.5-7.0)	10 U	42	
B8 (8.0-9.0)	10 U	15	
B9 (1.5-2.5)	10 U	23	
B9 (6.5-7.5)	10 U	10 U	
B10 (2.5-3.0)	10 U	41	
B10 (8.5-9.0)	10 U	10 U	
B11 (0.5-1.5)	10 U	14	
B11 (5.5-6.0)	10 U	25000	(JP-5)
B11 (7.0-7.5)	10 U	1000	(JP-5)
B12 (0.5-1.5)	10 U	10 U	
B12 (5.5)	10 U	9500	(JP-5)
B12 (7.0-7.5)	10 U	10 U	
B13 (0.5-1.5)	10 U	10 U	
B13 (6.0-6.5)	10 U	8800	(JP-5)

NOTES:
Analyzed by WTPH-HCID
(1) Petroleum hydrocarbons fingerprinted as JP-5 by laboratory.
U = Indicates compound was analyzed for but not detected at the given detection limit.

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TABLE 2

NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
PCBs
(mg/kg)

Sample ID	PCBs	Sample ID	PCBs	
Surface samples:		Sub-surface samples:		
SS-1	0.410	B1 (0.5-1.0)	0.320	U
SS-2	0.960	B1 (8.0-9.0)	0.320	U
SS-3	0.174			
SS-4	1.66	B2 (0.5-1.0)	0.320	U
SS-5	0.330	B2 (7.0-7.5)	0.320	U
SS-6	0.110			
SS-7	0.530	B3 (0.0-1.0)	0.760	U
		B3 (7.5-8.5)	0.320	U
		B4 (0.5-1.0)	2.70	
		B4 (4.1-4.4)	0.320	U
		B4 (8.0-9.0)	0.320	U
		B5 (1.5-3.0)	0.110	
		B5 (7.0-7.5)	0.320	U
		B6 (4.1-4.4)	0.320	U
		B7A (3.0-4.0)	0.340	U
		B8 (1.5-2.0)	0.320	U
		B8 (8.0-9.0)	0.320	U
		B9 (1.5-2.5)	0.340	U
		B10 (0.5-1.0)	0.400	
		B10 (9.0-9.5)	0.320	U
		B11 (0.5-1.5)	0.320	U
		B11 (4.0-4.5)	0.930	J
		B11 (7.0-7.5)	0.320	J
		B12 (0.5-1.5)	0.320	
		B13 (0.5-1.5)	0.320	U
		B13 (6.0-6.5)	0.320	UJ

NOTES:

PCBs analyzed by EPA Method 8080.
PCB concentration reported is the sum of 1016, 1242, 1248, 1254 and 1260 Aroclors.
U = Indicates compound was analyzed for but not detected at the given detection limit.
J = Indicates an estimated value when result is less than specified detection limit.

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TABLE 3
NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
(ug/kg)

Sample ID	Methylene Chloride	Acetone	1,1-Dichloroethane	Chloroform	1,2-Dichloroethane	2-Butanone	1,1,1-Trichloroethane	Carbon Tetrachloride	Bromodichloromethane	1,2-Dichloropropane	Dibromochloromethane	1,1,2-Trichloroethane	Bromoform	Toluene	Total Xylenes
Surface samples:															
SS-1	2.0 U	5.1 U	1.0 U	1.0 U	1.0 U	5.1 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U
SS-2	2.0 U	5.0 U	1.0 U	1.0 U	1.0 U	5.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	3.5	2.0 U
SS-3	2.0 U	5.0 U	1.0 U	1.0 U	1.0 U	5.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.9	2.0 U
SS-4	2.4 U	6.0 U	1.2 U	1.2 U	1.2 U	6.0 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.5 M	2.4 U
SS-5	2700 U	6800 U	1400 U	1400 U	1400 U	6800 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	21000
SS-6	2700 U	6600 U	1300 U	1300 U	1300 U	6600 U	1300 U	1300 U	1300 U	1300 U	1300 U	1300 U	1300 U	1300 U	5000
SS-7	6.5 U	5.7 U	1.1 U	1.1 U	1.1 U	5.7 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.2 M	2.3 U
Sub-surface samples:															
B1 (8.0-9.0)	2.5 U	6.2 U	1.2 U	1.2 U	1.2 U	6.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	2.5 U
B2 (7.0-7.5)	9.6	7.3 U	1.2 U	1.2 U	1.2 U	6.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	2.5 U
B3 (7.5-8.5)	4.8 U	7.7 U	1.2 U	1.2 U	1.2 U	6.1 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	2.4 U
B4 (8.0-9.0)	2300 U	1600 U	310 U	310 U	310 U	1600 U	310 U	310 U	310 U	310 U	310 U	310 U	310 U	310 U	630 U
B5 (7.0-7.5)	12 U	45 U	1.2 U	1.2 U	1.2 U	8.3	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	2.5 U
B6 (8.5-9.0)	5.1	11 U	1.2 U	1.1 J	1.2 U	6.0 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	0.8 J	2.4 U
B7 (1.0-1.5)	6.8 U	110 U	1.3 U	1.3 U	1.3 U	15	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3	1.8 J
B7A (3.0-4.0)	1000 U	410 U	390	440 J	380	970	330	330	350	350	310	340	290	71 J	320
B7A (10.0-10.5)	61 UJ	76 UJ	1.8 UJ	1.8 UJ	1.4 UJ	7.1 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	28 MJ	2.8 MJ
B8 (1.5-2.0)	7.6 U	82 U	1.1 U	1.1 U	1.1 U	7.9	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.6	2.2 U
B8 (8.0-9.0)	13 UJ	15 UJ	1.7 UJ	1.7 UJ	1.7 UJ	8.3 UJ	1.7 UJ	1.7 UJ	1.7 UJ	1.7 UJ	1.7 UJ	1.7 UJ	1.7 UJ	6.9 J	3.3 UJ
B9 (6.5-7.0)	3.5	7.5 U	1.3 U	1.3 U	1.3 U	6.6 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	2.7 U
B10 (8.5-9.0)	4.4	7.5 U	1.3 U	1.3 U	1.3 U	6.6 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	2.7 U
B11 (0.5-1.5)	4.4	7.9 U	1.0 U	1.0 U	1.0 U	5.2 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	9.0	1.9 U
B11 (4.0-4.5)	1400 U	3600 U	710 U	710 U	710 U	3600 U	710 U	710 U	710 U	710 U	710 U	710 U	710 U	710 U	1400 U
B11 (7.0-7.5)	1800	3900 U	170 U	170 U	170 U	990	170 U	170 U	170 U	170 U	170 U	170 U	170 U	170 U	330 U
B12 (7.0-7.5)	8.5 J	44 U	10 U	10 U	10 U	30 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
B13 (6.0-6.5)	330 U	830 U	170 U	170 U	170 U	830 U	170 U	170 U	170 U	170 U	170 U	170 U	170 U	170 U	330 U

NOTES:

Analyzed by EPA Method 8240.
U = Indicates compound was analyzed for but not detected at the given detection limit.
J = Indicates an estimated value when result is less than specified detection limit.
M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

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TABLE 4
NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
METALS
(mg/kg)

Sample ID	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Surface samples:									
SS-2	5 U	0.1	0.6	25.4	47.8	49	0.1	21	74.3
SS-5	5 U	0.1	0.9	18.3	35.3	77	0.1	19	78.9
Sub-surface samples:									
B1 (8.0-9.0)	6 U	0.1 U	0.2 U	11.7	17.4	4	0.1 U	5	22.6
B2 (0.5-1.0)	6 U	0.7	0.3	15.0	43.1	22	0.2	29	28.3
B3 (7.5-8.5)	6 U	0.1 U	0.2 U	10.2	15.2	5	0.05 U	5	22.6
B5 (1.5-3.0)	7 U	1.0	0.3 U	29.1	230	18	0.1 U	33	28.6
B5 (7.0-7.5)	6 U	0.1 U	0.3 U	12.3	14.9	12	0.1 U	7	48.9
B6 (4.1-4.4)	6 U	0.2	0.6	48.2	40.6	19	0.1	52	74.2
B8 (1.5-2.0)	5 U	0.1	0.2 U	16.7	17.0	10	0.1	12	33.5
B8 (8.0-9.0)	8 U	0.7	0.5	15.0	69.8	28	0.1 U	39	27.8
B9 (6.5-7.0)	6 U	0.3	0.4	20.4	52.0	19	0.1	16	46.7
B10 (2.5-3.0)	5 U	0.1	0.3	23.3	28.1	21	0.1	19	84.9
B11 (0.5-1.5)	5 U	0.3	0.4	20.6	40.8	111	0.1	17	54
B13 (5.5-6.0)	10	1.6	0.5	16.3	96.7	55	0.2	46	101

NOTES:
U = Indicates compound was analyzed for but not detected at the given detection limit.

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TABLE 5
NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
SUMMARY OF DETECTED SEMIVOLATILE ORGANIC COMPOUNDS
(ug/kg)

Sample ID	Phenol	4-Methyl-phenol	Naphthalene	2-Methyl-naphthalene	Dimethyl Phthalate	Acenaph-thylene	Acenaph-thene	Dibenzo-furan	Fluorene	Phenan-threne	Anthracene	Di-n-Butyl-phthalate	Fluoran-thene	Pyrene	Butyl-benzyl-phthalate
Surface samples:															
SS-2	130 U	66 U	66 U	66 U	66 U	66 U	66 U	66 U	66 U	66 U	66 U	65 J	83	71	66 U
SS-5	660 U	330 U	14000	25000	330 U	330 U	330 U	330 U	330 U	280 J	330 U	350	440	580	330 U
Sub-surface samples:															
B1 (8.0-9.0)	140 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U
B2 (0.5-1.0)	160 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U
B3 (7.5-8.5)	140 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U
B4 (0.5-1.0)	280	980	980	1700	41 M	66 U	66 U	64 J	50 M	230	35 J	530	210	220	310
B4 (8.0-9.0)	140 U	69 U	1600	5200	69 U	69 U	66 M	67 M	200	130	69 U	69 U	69 U	41 J	69 U
B5 (1.5-3.0)	160 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U
B5 (7.0-7.5)	150 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U
B7A (3.0-4.0)	250 U	120 U	510	1700	120 U	110 M	69 M	110 M	160	280	120 U	120 U	240	460	120 U
B8 (1.5-2.0)	130 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	64 U	37 J	64 U
B8 (8.0-9.0)	190 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U
B10 (9.0-9.5)	89 J	310	280	380	82 U	82 U	82 U	82 U	82 U	120	82 U	390 U	110	130	110
B11 (0.5-1.5)	120 U	61 U	61 U	61 U	61 U	61 U	61 U	61 U	61 U	33 J	61 U	61 U	35 J	33 J	61 U
B11 (4.0-4.5)	5700 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U	1500 J	2900 U
B13 (6.0-6.5)	710 U	350 U	350 U	350 U	350 U	350 U	350 U	350 U	240 J	290 J	350 U	330 UJ	350 U	350 U	350 U

NOTES:
Analyzed by EPA Method 8270.
U = Indicates analyte was analyzed for but not detected above the level indicated.
J = Indicates an estimated value when result is less than specified detection limit.
M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

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TABLE 5
NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
SUMMARY OF DETECTED SEMIVOLATILE ORGANIC COMPOUNDS
(ug/kg)

Sample ID	Benzo(a)-anthracene	bis(2-Ethyl-hexyl)-phthalate	Chrysene	Di-n-Octyl Phthalate	Benzo(b+k) fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd)-pyrene	Benzo(ghi) perylene
Surface samples:								
SS-2	51 J	110 U	83	66 U	170	70	66 U	66 U
SS-5	240 J	580 U	350	330 U	940	520	500	430
Sub-surface samples:								
B1 (8.0-9.0)	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U
B2 (0.5-1.0)	78 U	78 U	78 U	78 U	78 U	78 U	78 U	78 U
B3 (7.5-8.5)	70 U	70 U	70 U	70 U	70 U	70 U	70 U	70 U
B4 (0.5-1.0)	80	3900	140	600	140	160	160	220
B4 (8.0-9.0)	69 U	75	69 U	69 U	69 U	69 U	69 U	69 U
B5 (1.5-3.0)	78 U	83	78 U	78 U	78 U	78 U	78 U	78 U
B5 (7.0-7.5)	74 U	74 U	74 U	74 U	74 U	74 U	74 U	74 U
B7A (3.0-4.0)	83 M	550	150	120 U	210 M	67 M	120 U	120 U
B8 (1.5-2.0)	64 U	97	64 U	64 U	64 U	64 U	64 U	64 U
B8 (8.0-9.0)	94 U	94 U	94 U	94 U	94 U	94 U	94 U	94 U
B10 (9.0-9.5)	82 U	1900	56 J	140	130	71 J	82 J	78 J
B11 (0.5-1.5)	61 U	50 J	61 U	61 U	61 U	61 U	61 U	61 U
B11 (4.0-4.5)	2900 U	7200 J	2900 U	2900 U	2900 U	2900 U	2900 U	2900 U
B13 (6.0-6.5)	350 U	390 J	350 U	350 U	350 U	350 U	350 U	350 U

TABLE 6

NORTH BOEING FIELD - FIRE TRAINING CENTER
SOIL SAMPLE RESULTS - JULY 1992
SKYDROL™ ANALYSIS
(ug/kg)

Sample ID	Skydrol™ Component: Tributyl Phosphate		Dibutyl Phenol Phosphate		Butyl Diphenyl Phosphate		Triphenyl Phosphate		Sum of Four Components
B3 (7.5-8.5)	70	U	140	U	140	U	350	U	U
B4 (0.5-1.0)	26,000		2,200		1,100	M	3,300	U	29,300
B4 (8-9)	1,200		930		120		350	U	2,250
B6 (8.5-9.0)	55	U	110	U	110	U	270	U	U
B7 (1.5-2.0)	650		70	M	150	U	370	U	720
B7A (3-4)	3,700		170	J	250	U	620	U	3,870
B8 (1.5-2.0)	280		130	U	130	U	320	U	280
B11 (4.0-4.5)	96,000		18,000		11,000	U	29,000	U	114,000
B11 (5.5-6.0)	84,000		55,000		11,000		14,000	U	150,000
B13 (6.0-6.5)	2,200	M	710	U	710	U	1,800	U	2,200

U = Indicates analyte was analyzed for but not detected above the level indicated.
J = Indicates an estimated value when result is less than specified detection limit.
M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

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TABLE 7

NORTH BOEING FIELD - FIRE TRAINING CENTER
SUMMARY OF DETECTED COMPOUNDS
GROUNDWATER SAMPLES

Analysis		MW-1	MW-2	MW-3	MW-4
Total Petroleum Hydrocarbons (By Washington HCID)		No gas range or diesel range hydrocarbons detected at >= 3 mg/L			
Total Metals (Results in mg/L)	Arsenic	0.001 U	0.001 U	0.009	0.011
	Copper	0.004 U	0.007 U	0.008 U	0.006 U
	Lead	0.001 U	0.001 U	0.001 U	0.004 U
	Vanadium	0.002 U	0.003	0.029	0.011
	Zinc	0.004 U	0.007 U	0.004 U	0.013 U
PCBs (By Method 608)		None detected at >= 0.004 mg/L			
Volatile Organics (By Method 624)		None detected at >= 0.005 mg/L			
Semivolatile Organics (By Method 625) (Results in ug/L)	Di-n-Butylphthalate	0.6 J	0.5 J	0.5 J	1.0 U
	bis(2-ethylhexyl)phthalate	0.5 J	1.0 U	1.0 U	1.0 U
Skydrol™ (Results in ug/L)	Tributyl Phosphate	1 U	1 U	1 U	26
	Dibutyl Phenyl Phosphate	2 U	2 U	2 U	4.1
	Butyl Diphenyl Phosphate	2 U	2 U	2 U	2 U
	Triphenyl Phosphate	5 U	5 U	5 U	5 U

NOTES:
U = Indicates analyte was analyzed for but not detected above the level indicated.
J = Indicates an estimated value when result is less than specified detection limit.

I:\projects\boeing\nbf\gwsummry.wk1
10/26/92

Summary Information from Previous Investigations

Laucks
Testing Laboratories, Inc.
940 South Harney Street, Seattle, Washington 98108 (206) 767-5060
Chemistry, Microbiology, and Technical Services

Certificate

CLIENT Boeing Co.
P.O. Box 3707
Seattle, WA 98124
ATTN: Kirk Thompson M/S 9A-43

LABORATORY NO. 84718

DATE May 30, 1984

PO #B-315355

REPORT ON SEDIMENT

SAMPLE IDENTIFICATION

Sampled by us on May 14, 1984 at the Boeing Flight Center, Boeing Field, Seattle, WA.

TESTS PERFORMED AND RESULTS:

Samples 1,2, & 4 were sampled by shovel to a depth of approximately 3 inches and over an area 8" x 8". These samples were taken from under a few inches of standing water. Each sample was mixed well by means of a spatula in a stainless steel box and 1 quart of this material was brought back to the laboratory. Sample #3 was drawn from a depth of 12"-15" using a post hold type digger and scraping the sides of the hole at that depth. The mixing tool and box were rinsed with acetone and deionized water between each sample.

Samples 10 and 11 were surface samples taken with a shovel to a depth of approximately 0-6" over an area of 2 square feet.

Samples are identified as shown below: (see rough sketch of Fire Pit)

1) North Fire Pit - Location 1 - 0-3"
2) North Fire Pit - Location 2 - 0-3"
3) North Fire Pit - Location 3 - 12-15"
4) North Fire Pit - Location 4 - 0-3"
5) South Fire Pit - Location 1 - 0-3"
6) South Fire Pit - Location 2 - 0-3"
7) South Fire Pit - Location 3 - 0-3"
8) South Fire Pit - Location 4 - 0-3"
9) Off Site (40 ft. of Fire Pit) soil just below turf - 0-3"
10) Drainage Ditch (upstream of Fire Pit drain) - 0-6" - 2 sq. ft.
11) Drainage Ditch (downstream of Fire Pit drain) - 0-6" - 2 sq. ft.

Boeing Co.

	1	2	3	4	5	6
Total Solids, %	52.7	65.6	73.4	71.9	54.3	59.2

	7	8	9	10	11
Total Solids, %	63.5	57.2	80.2	85.5	75.3

parts per million (mg/kg), dry basis

	1	2	3	4	5	6
Lead	150.	150.	28.	73.	140.	51.
PCBs	0.61*	0.43*	L/0.05*	0.42*	0.89*	0.30*

	7	8	9	10	11
Lead	70.	150.	360.	56.	150.
PCBs	2.5*	0.79*	---	---	---
PCBs	---	---	0.10**	4.7**	8.9**

* Quantitated as Aroclor 1260, with obvious contribution from Aroclor 1254.
**Quantitated as Aroclor 1254, with obvious contribution from Aroclor 1260.

Samples 2, 8, & 11 were also analyzed for Gravimetric Polycyclic Aromatic Hydrocarbons in accordance with Washington State Department of Ecology WAC 173-303. The method requires analysis of the sample through successive stages until the result obtained is less than 1% by weight (as received basis) or until the fourth stage has been completed. Results are as shown on following page.

Sample coordinates represent the approximate locations (in feet) of the sites from which the samples were taken. All sample locations (except that for sample #3) were determined randomly.

Sample No.	Coordinates*
1	29, 2
2	3, 10
3	5, 55
4	34, 36
5	115, 28
6	70, 18
7	84, 48
8	98, 32

*First number is row, second number is column.

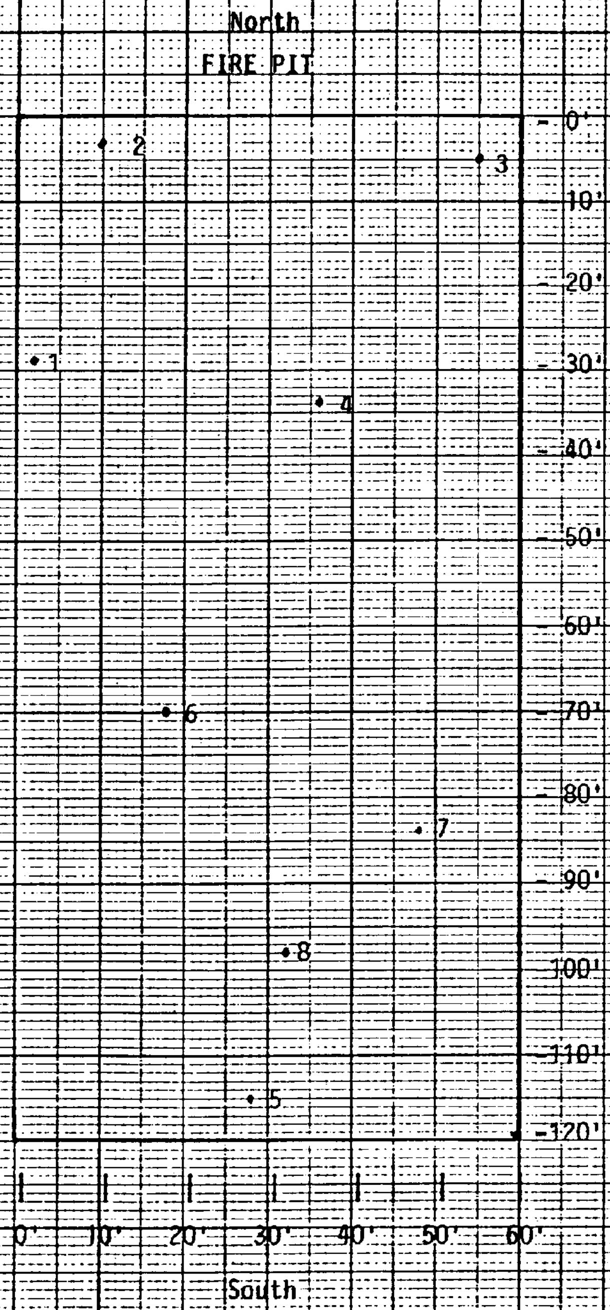
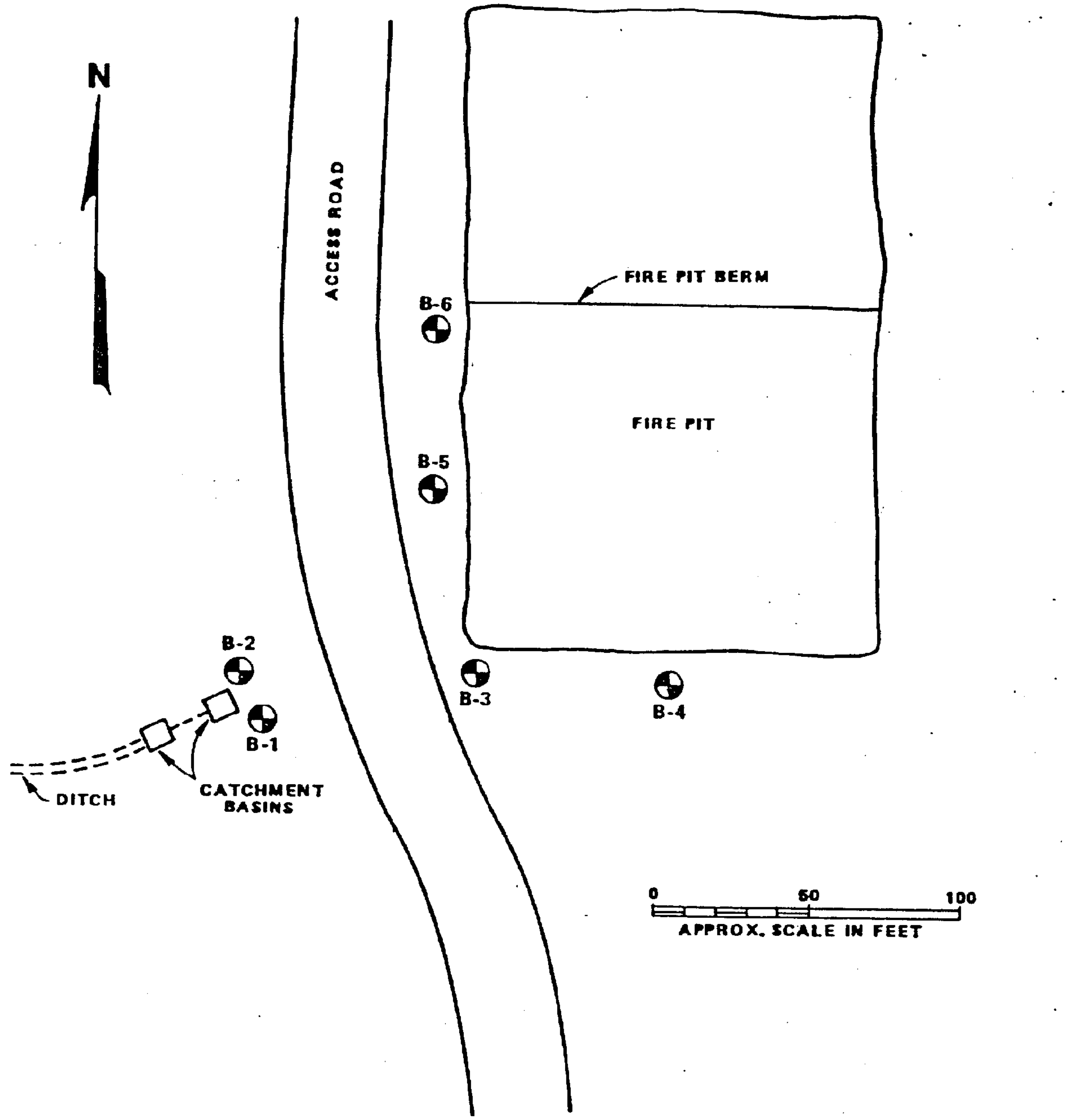


FIGURE 1. SOIL BORING LOCATION MAP, NORTH BOEING FIELD FIRE PRACTICE PIT



SHANNON & WILSON, INC.
Geotechnical Consultants

W-4136-01

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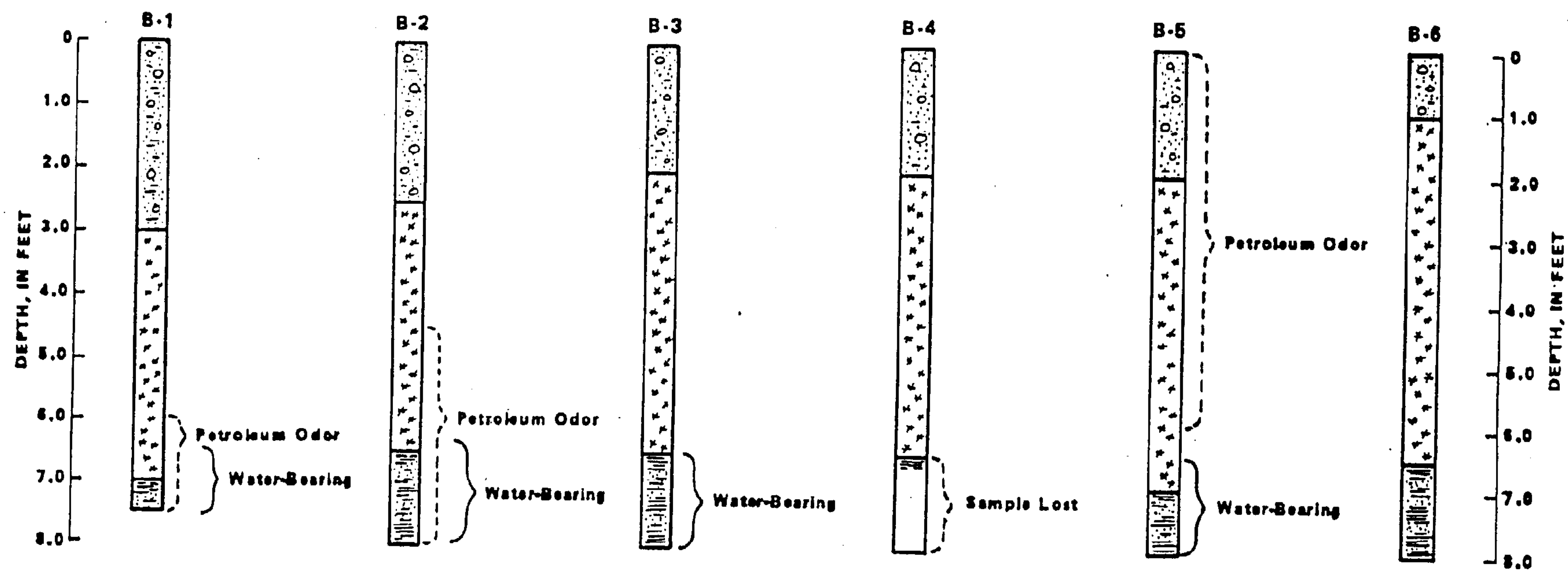
FIGURE 2. SOIL BORING LOGS, NORTH BOEING FIELD FIRE PRACTICE PIT



GEOLOGY

Silty, gravelly, fine SAND, grades from very fine to coarse sand with medium to coarse gravel, gray (Fill Material)

COAL, CINDER, and BRICK fragments, black, red, and tan (Fill Material)

Fine sandy SILT, interbedded with silty fine SAND, grey, with wood fragments.

MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

CH2M HILL

PROJECT NUMBER	WELL NUMBER	
SA29Sb.D0	NBF-MW1	SHEET 1 OF 4

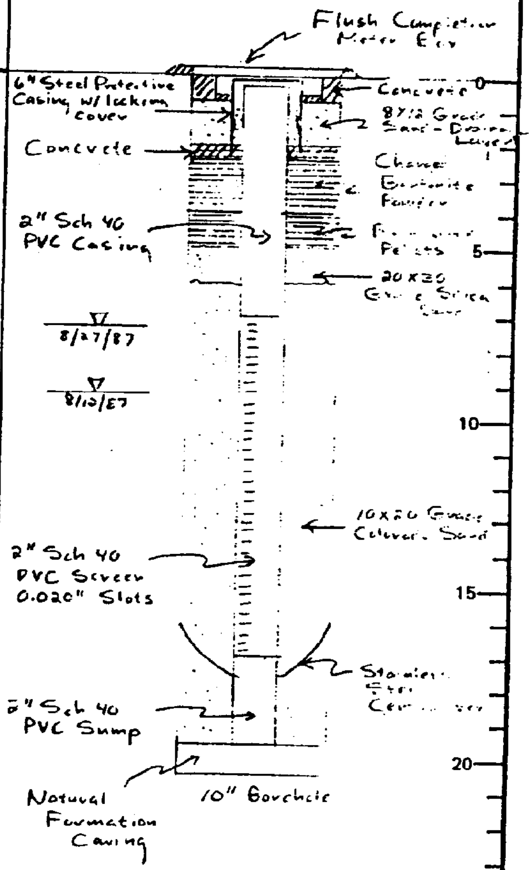
PROJECT BCAC- Five Pit Monitoring Wells LOCATION North Boeing Field

ELEVATION, NGVD (Top of Well Casing) 12.79' SURFACE ELEVATION, NGVD 13.45'

WATER LEVEL ELEVATION, NGVD 5.35' (8/27/87) START DATE 8/12/87 FINISH DATE 8/12/87

DRILLING CONTRACTOR Pacific Testing Laboratories DRILLING METHOD hollow stem auger

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGIC LOG & USCS DESIGNATION	HYDROLOGIC UNIT
0–1	70	15-14-14	Gravelly sandy silt (ML/SM) grading to silty sand (SM) 1-1.5 ft.	Vadose Zone
2–3	50	2-3-6	Burnt oil - ashes overlying reddish silty sand (SM)	Vadose Zone
5	50	1-2-1	Silty sand (SM) - brown to black layered with ashes (5.5-6.5 ft)	Vadose Zone
7–8	60	3-8-7	Ashes layered with black sandy silt (ML/SM) grading to black, medium silty sand (SM) at approx. 8.5 feet	
10	70	1-3-3	Sand - medium, black (SP)	Aquifer
12–13	70	1-2-1	Sand - well graded (SW) fine to med interbedded with approx 3" of tight silt (ML) slightly sandy at approx 13 feet	Aquifer
15	50		Sand - well graded to med. (SW) some coarse sand to 1/4" minus gravel	Aquifer
20	80		Sand - poorly graded (SP) black Heaving	Aquifer



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MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

CH2M HILL

PROJECT NUMBER	WELL NUMBER	
522959.C0	NBF-MW2	SHEET 6 OF 5

PROJECT BCAC- Five Pit Monitoring Wells LOCATION North Boeing Field

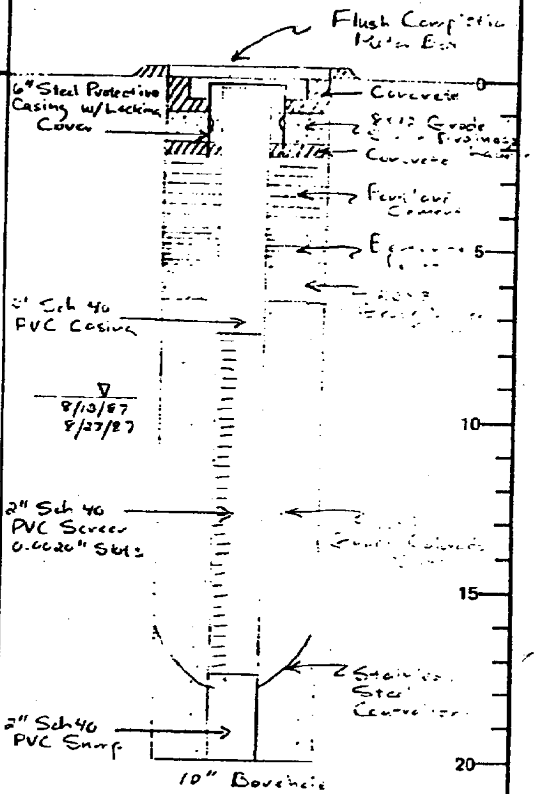
ELEVATION, NGVD (Top of Well Casing) 15.04' SURFACE ELEVATION, NGVD 15.43'

WATER LEVEL ELEVATION, NGVD 5.50' (8/27/87) START DATE 8/13/87 FINISH DATE [illegible]

DRILLING CONTRACTOR [illegible] DRILLING METHOD hollow stem auger

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGIC LOG & USCS DESIGNATION	HYDROLOGIC UNIT
0		8-13-14	Sand – brown silty sand fine to medium, well-graded (SM/SW) tarry material at base of silty sand (3.5 ft)	Vadose Zone
		3-3-1/2	Gravel – sandy graded to 1" minus (GW)	
5	50	5-8-10	Gravel – silty gravel (½" minus) to sand grading to black coal-like material grading to brown gravelly silt (ML/GM)	
	60	6-7-9	Sand – brown silty sand (SM) with rust staining 2" layer of tarry material mixed with very plastic black silt (MH)	
10	70	4-5-4	Sand – well graded, fine to medium with some ¼" minus gravel (SW)	Aquifer
	60	1-0-0		
15	60	1-3-5	Black, tight silt layer (ML) from approx 16-16.5'	
	100	5-5-6	Sand – fine to coarse, well graded (SW)	
20				
25				

WELL CONSTRUCTION



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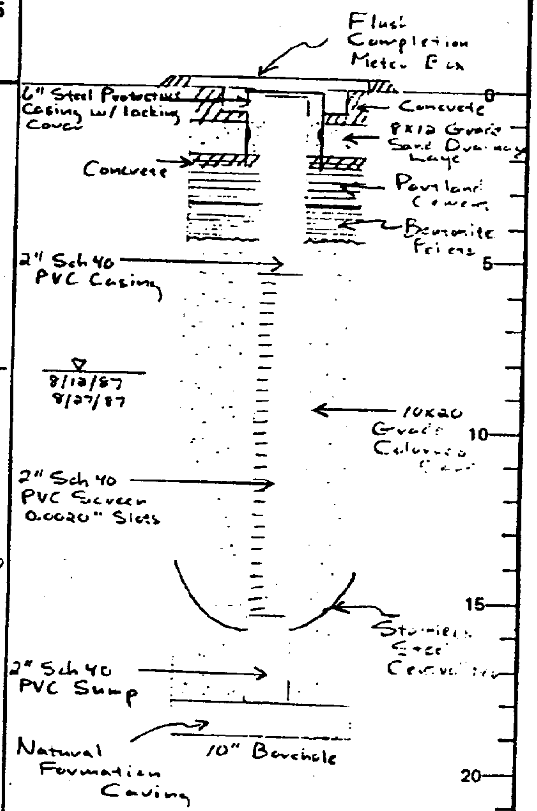
MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

PROJECT NUMBER	WELL NUMBER	
S22959.D0	NBF-MW3	SHEET 3 OF 5

PROJECT ECAC - Five Fn Monitoring Wells LOCATION North Boeing Field
ELEVATION, NGVD (Top of Well Casing) 15.14' SURFACE ELEVATION, NGVD 15.68'
WATER LEVEL ELEVATION, NGVD 6.54' (8/27/87) START DATE 8/12/87 FINISH DATE
DRILLING CONTRACTOR Pacific Testing Laboratories DRILLING METHOD hollow stem auger

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGIC LOG & USCS DESIGNATION	HYDROLOGIC UNIT
0	50	18-12-5	Gravel - silty, cobbly (GW) / Silt - brown with black tar-like and organic materials (ML)	Vadose Zone
	100	4-6-8	Silt to Sandy Silt (ML/SM) - brown that with rust-colored areas throughout sample	Vadose Zone
5	100	3-8-9	Sand - fine to medium, dry, dark brown to beige (SP)	Vadose Zone
	100	3-3-4	Sand - brown, wet, well-graded (SW) Water at approx. 8-9 feet	Vadose Zone
10	60	1-2-2	Rust staining at approx 11 feet	Aquifer
	100	4-11-14	Sand - brown, medium (SP) Heaving problems at 12.5 ft	Aquifer
15	100	2-6-8	Sand - well-graded fine to coarse, brown/rust colored (SW) / Sand - black poorly graded fine sand (SP)	Aquifer
	100	1-6-10	Sand - well-graded, brown some fines (SW)	Aquifer
20				
25				

WELL CONSTRUCTION



CH2M HILL

MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

PROJECT NUMBER	WELL NUMBER	
522959.C0	NBF-MW4	SHEET 4 OF 5

PROJECT BCAC - Fire Pit Monitoring Wells LOCATION North Boeing Field
ELEVATION, NGVD (Top of Well Casing) 14.46' SURFACE ELEVATION, NGVD 14.21
WATER LEVEL ELEVATION, NGVD 6.40' (8/27/87) START DATE 8/11/87 FINISH DATE 8
DRILLING CONTRACTOR Pacific Testing Laboratories DRILLING METHOD hollow stem auger

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGIC LOG & USCS DESIGNATION	HYDROLOGIC UNIT
	100	9-9-8	Gravel - sandy, silty (GW) grading to (SM/SP)	Vadose Zone
	70	2-2-2	Sand - brown, dry (SM)	Vadose Zone
5	100	1-1-2	Silt - brown (ML) with some material that looks like oil at approx 6.5 feet	Vadose Zone
	100	0-2-2	Silt - saturated (ML) interbedded with slightly silty sand (SW)	
10	100	0-1-1	Sand - well-graded (SW) Water at approx. 8-9 feet	Aquifer
	0	0-1-5	Heaving problems at 12.5 ft.	Aquifer
15				
20				
25				

WELL CONSTRUCTION

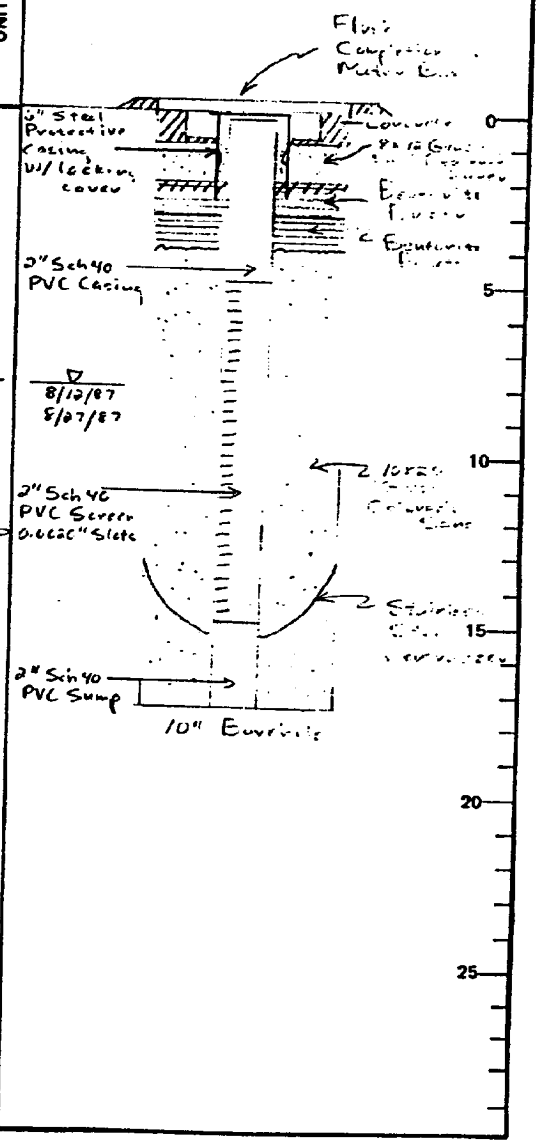


Table 1
Groundwater Sampling Analysis Summary
North Boeing Field Fire Drill Pit

CONSTITUENT	NBF-MW-1		NBF-MW-2		NBF-MW-3		NBF-MW-4	
	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)
VOLATILE COMPOUNDS								
Chloromethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Bromomethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Vinyl chloride	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Chloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Methylene chloride	13	5	31	5	18	5	26	5
Trichlorofluoromethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Acetone	BMDL	10	BMDL	10	12	10	BMDL	10
Carbon disulfide	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,1-Dichloroethene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,1-Dichloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Trans-1,2-dichloroethene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Chloroform	BMDL	5	BMDL	5	BMDL	5	BMDL	5
2-Butanone	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,2-Dichloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,1,1-Trichloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Carbon tetrachloride	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Vinyl acetate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Bromodichloromethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,2-Dichloropropane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Trans-1,3-dichloropropene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Trichloroethene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Benzene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Dibromochloromethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,1,2-Trichloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Cis-1,3-dichloropropene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
2-Chloroethylvinylether	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Bromoform	BMDL	5	BMDL	5	BMDL	5	BMDL	5
4-Methyl-2-pentanone	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Hexanone	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Tetrachloroethene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
1,1,2,2-Tetrachloroethane	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Toluene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Chlorobenzene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Ethyl Benzene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Styrene	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Total Xylenes	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Acrylonitrile	BMDL	100	BMDL	100	BMDL	100	BMDL	100
Acrolein	BMDL	100	BMDL	100	BMDL	100	BMDL	100

Notes: MDL - Method Detection Limit   ppb - parts per billion (ug/L)
BMDL - Below Method Detection Limit

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Table 1 continued
Groundwater Sampling Analysis Summary
North Boeing Field Fire Drill Pit

CONSTITUENT	NBF-MW-1		NBF-MW-2		NBF-MW-3		NBF-MW-4	
	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)
BASE/NEUTRAL COMPOUNDS								
Aniline	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Bis (2-chloroethyl) ether	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,3-Dichlorobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,4-Dichlorobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzyl Alcohol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,2-Dichlorobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Bis (2-chloroisopropyl) ether	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Hexachloroethane	BMDL	10	BMDL	10	BMDL	10	BMDL	10
N-nitroso-di-n-propylamine	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Nitrobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Isophorone	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Bis(2-chloroethoxy) methane	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,2,4-Trichlorobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Naphthalene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
4-Chloroaniline	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Hexachlorobutadiene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Methylnaphthalene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Hexachlorocyclopentadiene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Chloronaphthalene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
3-Nitroaniline	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Acenaphthylene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Dimethyl phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,6-Dinitrotoluene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Nitroaniline	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Acenaphthene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Dibenzofuran	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4-Dinitrotoluene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Fluorene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
4-Chlorophhenyl phenyl ether	BMDL	10	BMDL	10	BMDL	10	BMDL	10
4-Nitroaniline	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Diethyl phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
N-nitrosodiphenylamine	BMDL	10	BMDL	10	BMDL	10	BMDL	10
1,2-Diphenylhydrazine	BMDL	10	BMDL	10	BMDL	10	BMDL	10
4-Bromophenyl phenyl ether	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Hexachlorobenzene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Phenanthrene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Anthracene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Dibutyl phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10

Notes: MDL - Method Detection Limit
BMDL - Below Method Detection Limit
ppb - parts per billion (ug/L)

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SEA404499

Table 1 continued
Groundwater Sampling Analysis Summary
North Boeing Field Fire Drill Pit

CONSTITUENT	NBF-MW-1		NBF-MW-2		NBF-MW-3		NBF-MW-4	
	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)
BASE/NEUTRALS (con't)								
Fluoranthene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Pyrene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzidine	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Butyl benzyl phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,3,7,8-Tetrachlorodibenzo-p-dioxin	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzo (a) anthracene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Chrysene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
3,3'-Dichlorobenzidine	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Bis(2-ethylhexyl)phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Di-n-octyl phthalate	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzo (b) fluoranthene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzo (k) fluoranthene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzo (a) pyrene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Indeno (1,2,3-cd) pyrene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Dibenzo (a,h) anthracene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzo (g,h,i) perylene	BMDL	10	BMDL	10	BMDL	10	BMDL	10
ACID COMPOUNDS								
Phenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Chlorophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
O-Cresol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
M & P-Cresol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2-Nitrophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4-Dimethylphenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4-Dichlorophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Benzoic Acid	BMDL	50	BMDL	50	BMDL	50	BMDL	50
4-Chloro-3-methylphenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4,6-Trichlorophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4,5-Trichlorophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10
2,4-Dinitrophenol	BMDL	50	BMDL	50	BMDL	50	BMDL	50
4-Nitrophenol	BMDL	50	BMDL	50	BMDL	50	BMDL	50
2-Methyl-4,6-dinitrophenol	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Pentachlorophenol	BMDL	10	BMDL	10	BMDL	10	BMDL	10

Notes: MDL - Method Detection Limit ppb - parts per billion (ug/L)
BMDL - Below Method Detection Limit

Table 1 continued
Groundwater Sampling Analysis Summary
North Boeing Field Fire Drill Pit

CONSTITUENT	NBF-MW-1		NBF-MW-2		NBF-MW-3		NBF-MW-4	
	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)	Conc. (ppb)	MDL (ppb)
PCB/PESTICIDES								
a-BHC	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
b-BHC	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
g-BHC	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
d-BHC	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Heptachlor	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Aldrin	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Heptachlor Epoxide	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Endosulfan I	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Dieldrin	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
4,4-DDE	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Endrin	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Endosulfan II	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
4,4-DDD	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Endrin Aldehyde	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Endosulfan Sulfate	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
4,4-DDT	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Methoxychlor	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Chlordane	BMDL	0.1	BMDL	0.1	BMDL	0.1	BMDL	0.1
Toxaphene	BMDL	1	BMDL	1	BMDL	1	BMDL	1
PCB-1221	BMDL	2	BMDL	2	BMDL	2	BMDL	2
PCB-1232	BMDL	2	BMDL	2	BMDL	2	BMDL	2
PCB-1242	BMDL	1	BMDL	1	BMDL	1	BMDL	1
PCB-1016	BMDL	1	BMDL	1	BMDL	1	BMDL	1
PCB-1248	BMDL	0.5	BMDL	0.5	BMDL	0.5	BMDL	0.5
PCB-1254	BMDL	0.2	BMDL	0.2	BMDL	0.2	BMDL	0.2
PCB-1260	BMDL	0.2	BMDL	0.2	BMDL	0.2	BMDL	0.2
METALS (Total Filterable)								
Antimony	BMDL	250	BMDL	250	BMDL	250	BMDL	250
Arsenic	BMDL	5	BMDL	5	5	5	12	5
Barium	BMDL	100	BMDL	100	BMDL	100	BMDL	100
Beryllium	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Cadmium	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Chromium	BMDL	20	BMDL	20	BMDL	20	BMDL	20
Copper	BMDL	25	BMDL	25	BMDL	25	BMDL	25
Lead	BMDL	50	BMDL	50	BMDL	50	BMDL	50
Mercury	BMDL	0.2	BMDL	0.2	BMDL	0.2	BMDL	0.2
Nickel	BMDL	40	BMDL	40	BMDL	40	BMDL	40
Selenium	BMDL	5	BMDL	5	BMDL	5	BMDL	5
Silver	BMDL	10	BMDL	10	BMDL	10	BMDL	10
Thallium	BMDL	60	BMDL	60	BMDL	60	BMDL	60
Zinc	BMDL	20	BMDL	20	BMDL	20	BMDL	20

Notes: MDL - Method Detection Limit
BMDL - Below Method Detection Limit
ppb - parts per billion (ug/L)

APPENDIX B

Boring Logs

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL (1)	TYPICAL DESCRIPTIONS (2)(3)
COARSE-GRAINED SOIL (More than 50% of material is larger than No.200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No.4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No.4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No.200 sieve size)	SILT AND CLAY (Liquid Limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid Limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand or silty soil
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

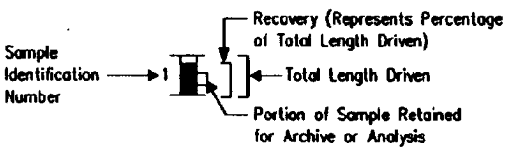
Notes: 1. USCS letter symbols correspond to the symbols used by the Unified Soil Classification System and ASTM Classification methods. Dual letter symbols (e.g., SM-SP) for a sand or gravel indicate a soil with an estimated 5-15% fines. Multiple letter symbols (e.g.,ML/CL) indicate borderline or multiple soil classifications.

2. Soil classifications are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D2487.

3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows: Primary Constituent: (>50%) - "GRAVEL," "SAND," "SILT," "CLAY," etc.
   - Secondary Constituents: >30% and ≤50% - "very gravelly," "very sandy," "very silty," etc.
   - >15% and ≤30% - "gravelly," "sandy," "silty," etc.
   - Additional Constituents: >5% and ≤15% - "with gravel," "with sand," "with silt," etc.
   - ≤5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

Key

SAMPLE NUMBER & INTERVAL



PID

Description

Photoionization Reading above freshly opened sample (in ppm)

SAMPLER TYPE

Code	Description
1	3.25-inch O.D., 2.42-inch Split Spoon Sampler
2	2.00-inch O.D., 1.50-inch Split Spoon Sampler
3	Grab Sample
a	300-lb Hammer, 30-inch Drop
b	140-lb Hammer, 30-inch Drop
c	Pushed

OTHER

▽ ATD — Approximate Water Elevation At Time of Drilling or On Date Noted

28068.10 Boeing/North Boeing Field Fire Training Area/Site Investigation 10/92

Soil Classification System and Key

Figure B-1

KCSlip4 37973

SEA404503

B1

Drilling Method: Driven Open Hole

Ground Elevation (ft): 15.9 ft (NGVD)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Soil Profile
0	B1 (0.5-1.0)	1b	43	0.0	SP	Light brown, silty fine SAND with trace coal, gravel and asphalt (loose, dry) (fill) (blow counts not representative of soil density)
					ML/SM	Gray with rust mottling, fine sandy SILT to silty, fine SAND (medium stiff to medium dense, moist)
		1b	39	0.2	SM	Light gray with rust mottling, very fine SAND with silt (medium dense, moist)
3	B1 (4.0-4.5)	1b	34	0.1	SP	Dark gray, very fine to fine SAND with trace silt (medium dense, moist to wet)
		1b	38	0.0		
6		1b	35	0.0		
	B1 (8.0-9.0)	1b	26	0.0		ATD
9						

Boring Completed 7/29/92
Total Depth : 9.0 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25058.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B1

Figure B-2

B2

SAMPLE DATA					SOIL PROFILE	
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Drilling Method: Driven Open Hole Ground Elevation (ft): 14.6 ft (NGVD)
0					GP	Light brown, sandy GRAVEL with grass and roots
	B2 (0.5-1.0)	1b	41	0.0		Granular coal and ash (fill)
					ML	Brown with rust mottling, very fine sandy SILT with organics (medium stiff, moist)
		1b	41	0.0	SM	Dark gray with rust mottling, silty very fine SAND with trace organics (medium dense, moist)
3						
		1b	37	0.0	SP	Dark gray with rust mottling, fine SAND with trace silt (medium dense, moist to wet)
		1b	32	0.0		
6						
	B2 (7.0-7.5)	1b	26	0.0		ATD
9						
12						
15						

Boring Completed 7/29/92
Total Depth = 7.5 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

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Log of Boring B2

Figure B-3

B3

SAMPLE DATA / SOIL PROFILE

Drilling Method: Driven Open Hole

Ground Elevation (ft): 15.7 ft (NGVD)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Description
0	B3 (0.0-1.0)	1b	35	0.0	SM	Light to dark brown, silty fine SAND with organics and trace coal (medium dense, moist) (fill)
		1b	40	0.0	ML	Light brown with rust mottling, fine, sandy SILT (medium stiff, moist)
3		1b	39	0.0	ML/SM	Light gray, silty very fine SAND to sandy SILT (medium dense to medium stiff, moist)
		1b	38	0.0	SP	Dark gray, fine SAND (medium dense, moist to wet)
6		1b	34	0.0		
	B3 (7.5-8.0)	1b	21	0.0		ATD
9						

Boring Completed 7/29/92
Total Depth = 9.0 ft

Depth scale: 12, 15

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

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Log of Boring B3

Figure B-4

B4

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Soil Profile
0	B4 (0.5-1.0)	1b	21	30	GP	Light brown, very sandy GRAVEL with trace coal fragments and hydrocarbon odor (loose, dry) (fill)
					ML	Medium brown SILT with trace organics and hydrocarbon odor (medium stiff, moist)
	B4 (2.5-3.0)	1b	25	226	SM	Dark brown to black, silty, very fine SAND with hydrocarbon odor (loose, moist)
3	B4 (4.0-4.5)	1b	17	103		
	B4 (5.5-6.0)	1b	17	150	SP	Dark brown, very fine SAND with silt and hydrocarbon odor (loose, moist)
6	B4 (7.0-7.5)	1b	21	63		
	B4 (8.0-9.0)	1b	26	57		Dark gray, very fine to fine SAND with hydrocarbon odor (medium dense, wet) ∇ ATD
9						

Drilling Method: Driven Open Hole

Ground Elevation (ft): 15.6 ft (NGVD)

Boring Completed 7/29/92
Total Depth = 9.0 ft

12

15

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25068.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B4

Figure B-5

B5

SAMPLE DATA / SOIL PROFILE

Drilling Method: Driven Open Hole

Ground Elevation (ft): 14.2 ft (NGVD)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Description
0						SP	Medium brown, gravelly SAND with some silt (medium dense, dry) (fill)
		1b	40	0.0			Granular coal and ash with some brick fragments (medium dense, moist) (fill)
	B5 (1.5-3.0)	1b	41	0.0			
3							
		1b	34	0.5			
	B5 (5.5-6.0)	1b	27	0.2			
6							
	B5 (6.0-7.5)	1b	17	0.2			
						SP	Dark gray, very fine to fine SAND with silt (loose, wet) ▽ ATD
9							
12							
15							

Boring Completed 7/29/92
Total Depth = 7.5 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

20068.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B5

Figure B-6

B6

Drilling Method: Driven Open Hole

Ground Elevation (ft): 14.9 ft (NGVD)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Profile
0		1b	80	0.0		SP	Tan, very gravelly very fine SAND (dense, dry) (fill)
	B6 (2.5-3.0)	1b	175	0.0		GP	Brown, silty GRAVEL with sand (loose, moist) (fill)
3		1b	90	0.0			
						SM	Gray, silty, very fine SAND with trace gravel (medium dense, moist) (fill)
		1b	65	0.0		SP	Dark brown, fine SAND with silt and trace gravel (dense, moist) (fill)
6		1b	27	0.0			
	B6 (8.0-9.0)	1b	16	0.0			Granular pink and white ash (loose, moist) (fill) ▽ ATD
9						SP	Dark brown with rust mottling fine SAND (loose, wet) (fill)
12							
15							

Boring Completed 7/30/92
Total Depth : 9.0 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

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Log of Boring B6

Figure B-7

B7/7A

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: 4" Hollow Stem Auger/ Driven Open Hole Ground Elevation (ft): 15.5 ft (NGVD)
0	B7 (1.0-1.5)	1b	39	27		SP	Dark brown, very fine to fine SAND with some silt and gravel (medium dense, moist) (fill)
	B7 (1.5-2.0)	1b	100	7			
3	B7 (3.0-4.0)	1b	28	105		GP	Dark brown, very sandy GRAVEL with hydrocarbon odor (loose, moist) (fill)
	B7 (4.5-6.0)	1b	19	45		SP	Dark brown, very fine to fine SAND (loose, moist) (fill)
6	B7 (6.5-7.0)	1b	19	2.4			
		1b	30	0.0			Granular coal, brick, and pink to white ash (medium dense to dense, moist) (fill)
9	B7 (10.0-10.5)	1b	109	3.0			▽ ATD
12							
15							

Boring Completed 7/29/92
Total Depth = 10.5 ft

NOTE: Refusal at 3.0' in B7; Geology from 3.0' to 10.5' from B7A drilled 7.0' to the south of B7.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

Log of Boring B7/7A

Figure B-8

B8

Drilling Method: Driven Open Hole

Ground Elevation (ft): 14.7 ft (NGVD)

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	
0		1b	87	17		SM	Dark brown, silty fine SAND with gravel and hydrocarbon odor (dense, moist) (fill)
	B8 (1.5-2.0)	1b	98	0.0			
3		1b	42	0.0			Granular coal and pink to white ash with some brick fragments and fine silty sand (loose to medium dense, moist to wet) (fill)
		1b	17	0.0			
6	B8 (6.5-7.0)	1b	17	0.0			
	B8 (7.5-9.0)	1b	22	0.0			ATD
9							
12							
15							

Boring Completed 7/29/92
Total Depth = 9.0 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

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Log of Boring B8

Figure B-9

KCSlip4 37981

SEA404511

B9

Drilling Method: Driven Open Hole

Ground Elevation (ft): 16.0 ft (NGVD)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Profile
0			87	0.0		SM	Medium brown, silty SAND with gravel (very dense, dry) (fill)
	B9 (1.5-2.5)		25	0.0		SP	Medium brown, very gravelly SAND with trace silt (medium dense, moist) (fill)
3			4	0.0			Granular coal, brick, and pink to white ash (very loose, moist) (fill)
			7	0.0			
6	B9 (6.5-7.5)		16	0.0		SM	Dark brown, silty fine SAND (loose, wet) ATD

Boring Completed 7/30/92
Total Depth = 7.0 ft

Depth scale (ft): 0, 3, 6, 9, 12, 15

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

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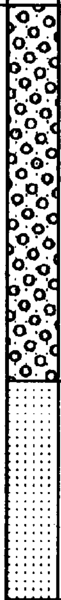
Log of Boring B9

Figure B-10

·B10

SAMPLE DATA				SOIL PROFILE		
						Drilling Method: Driven Open Hole
						Ground Elevation (ft): 15.5 ft (NGVD)
Depth (ft)	**Sample Number & Interval**	**Sampler Type**	**Blows/Foot**	**PID (ppm)**	**Graphic Symbol** / **USCS Symbol**	
0					GP	Light to dark brown, very sandy GRAVEL with some silt (loose, dry to moist) (fill)
	B10 (1.0-1.5)	1b	113	0.0		
	B10 (1.5-2.0)	1b	80	0.0		
3						Small cobbles
6					SP	Dark brown, fine SAND (very dense, moist) (fill)
		1b	60	0.0		
	B10 (8.5-9.0)	1b	38	0.0		
9						Granular coal and ash (dense, moist to wet) (fill) ∇ ATD
	B10 (9.0-9.5)	1b	82	0.0		
12						
15						



Boring Completed 7/30/92
Total Depth = 10.5 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25058.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B10 | **Figure B-11**

B11

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Driven Open Hole Ground Elevation (ft): 12.8 ft (NGVD)
0	B11 (0.5-1.5)	1b	24	0.0		SP	Medium brown, very gravelly fine SAND with some silt (loose, moist) (fill)
		1b	35	0.0			
3	B11 (4.0-4.5)	1b	47	20			Granular coal and pink to tan ash with hydrocarbon odor (loose to medium dense, moist) (fill)
	B11 (5.5-6.0)	1b	18	30			ATD
6	B11 (7.0-7.5)	1b	20	80		SP	Black, fine SAND with hydrocarbon odor and trace wood (loose, wet)

Boring Completed 7/30/92
Total Depth = 7.5 ft

9

12

15

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25068.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B11

Figure B-12

KCSlip4 37984

SEA404514

B12

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Driven Open Hole Ground Elevation (ft): 12.6 ft (NGVD)
0	B12 (0.5-1.5)	1b	65	0.0		SP	Dark brown, very gravelly SAND with trace silt (medium dense, moist) (fill)
		1b	43	0.0			
3		1b	32	28			Granular coal and pink to white ash (medium dense, moist) (fill)
	B12 (5.5-6.0)	1b	22	50			ATD
6						ML	Medium brown, fine sandy SILT with organics and hydrocarbon odor (medium stiff, moist)
	B12 (7.0-7.5)	1b	21	60		SP	Dark brown, fine SAND (loose, wet)

Boring Completed 7/30/92
Total Depth = 7.5 ft

9

12

15

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25058.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B12

Figure B-13

KCSlip4 37985

SEA404515

B13

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Driven Open Hole Ground Elevation (ft): 12.6 ft (NGVD)
0	B13 (0.5-1.5)	1b	7	0.0		SP	Dark brown, silty SAND with trace organics and gravel (loose, moist) (fill)
		1b	9	0.0			
3		1b	12	0.0			Granular coal and pink to white ash (very loose, moist) (fill)
	B13 (5.5-6.0)	1b	7	52			
6	B13 (6.0-6.5)	1b	13	78		SP	ATD Dark brown, fine SAND with strong hydrocarbon odor (loose, wet)
9							
12							
15							

Boring Completed 7/30/92
Total Depth = 7.5 ft

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Key and Soil Classification System" figure for explanation of graphics and symbols.

25068.10 Boeing/North Boeing Field Fire Training Center/Site Investigation 10/92

Log of Boring B13

Figure B-14

APPENDIX C

Field Procedures

APPENDIX C
FIELD PROCEDURES

This appendix describes the field procedures used during the investigation of soil and groundwater conditions at the NBF FTC.

SOIL BORINGS

A total of 13 soil borings were either drilled or driven using a truck-mounted, hollow-stem auger rig equipped with a hydraulic 140-lb hammer. Eleven of the borings were advanced as driven open holes, using a 2.42-inch ID, 24-inch long, split-spoon sampler driven on continuous 1.5-ft intervals from the ground surface to the groundwater surface. Two borings were drilled with 4-inch ID, hollow-stem augers when gravel was encountered which could not be penetrated with the driven sampler. The borings were all abandoned by backfilling with bentonite chips to the ground surface.

Once the split-spoon sampler was retrieved and opened, soil within the sampler was screened with a photoionization detector (PID) for volatile organic compounds. Selected samples were also screened by headspace analysis. A minimum of two samples per boring were collected for chemical analysis. One of the samples was collected from the unsaturated zone based on field screening results, the other sample was from the groundwater surface. Samples were collected for volatile organic analysis by inserting a 1.5-inch ID, 6-inch long, brass sample liner into the undisturbed sample, retrieving the liner, and covering both of its ends with teflon film and plastic end caps. The sample remaining in the split-spoon was then homogenized in a stainless-steel bowl and splits for other analyses were collected, if necessary. Occasionally, poor sample recovery prevented the collection of the volatile organic sample with a brass liner. In those cases, a glass jar was filled full of soil directly from the sampler using a spoon.

All sampling equipment was decontaminated by scrubbing with a solution of Alconox and tap water, followed by a tap water rinse, and a final distilled water rinse. Bowls and spoons were air dried and kept in plastic bags between use.

After sample collection, the sample jars and liners were put in a chilled cooler and hand delivered at the end of each day to Analytical Resources, Inc. Soil cuttings, decontamination fluids, and monitoring well purge water were collected into appropriately labeled 55-gal drums.

SURFACE SOIL SAMPLING

Locations for samples from the berms of the impoundment were determined by digging a series of small shovel holes along the berms, inserting a PID probe into each hole, and monitored. The locations with the highest PID readings were then sampled by collecting soil from a small shovel hole dug adjacent to the holes dug for field screening. The sample bottle for volatile organic analysis was filled directly from the shovel hole using a stainless-steel spoon. Other sample bottles were filled from a stainless steel bowl containing homogenized soil collected from the interior of the shovel hole.

The surface samples from the bottom of the impoundment were collected in a similar manner as the berms, except field screening was not conducted to determine sample locations. Instead, samples were collected based on obtaining representative aerial coverage of the impoundment bottom. The impoundment bottoms contained no standing water during the field program.

MONITORING WELLS

Redevelopment

The four existing monitoring wells were redeveloped 3 days prior to sampling by pumping the wells with a centrifugal pump until the purged water, which in all wells was initially turbid and silty, was clear. Prior to redevelopment, the wells were checked for free product by examining the water in an acrylic bailer after it was lowered several inches into the water. Approximately 10 gal were purged from each well during redevelopment.

Groundwater Sampling

The four existing monitoring wells were sampled by first measuring the depth to water with an electric tape to the nearest 0.01 ft. A minimum of three well casing volumes of water was then purged from each well with a centrifugal pump connected to a $\frac{5}{8}$-inch ID polyethylene purge tubes used for well redevelopment. After three well volumes were purged, the wells were sampled using a peristaltic pump connected to dedicated $\frac{3}{8}$-inch ID polyethylene tubing. The discharge rate of peristaltic pump was lowered when the bottles for volatile organic analysis were filled to prevent loss of volatiles by fluid turbulence. The samples for metals analysis were originally planned to be field filtered and preserved. However, the 0.2-micron filters created too much back pressure for the peristaltic pump to operate. Therefore, the metals samples were collected unfiltered. Any preservatives were rinsed out of the sample bottles prior to filling.

Conductivity, pH, and temperature were measured during sample collection. Conductivity and pH meters were calibrated, following procedures provided with the instrument, prior to commencement of sampling and at least once every four hours during sampling. Calibration adjustments were recorded in a logbook maintained with each meter. Four replicate field measurements were made and recorded on the sample collection form. All samples were placed in an iced cooler and hand delivered to a local laboratory at the end of the day. The Chain-of-Custody forms documenting sampling possession and testing parameters accompanied the samples during collection and transfer.

<u>Sample Location Survey</u>

All soil sample locations were identified and flagged by the field crew. Sample locations were surveyed for horizontal control by establishing a baseline off relatively permanent site feature (i.e., southeast corner of Seattle City Light building). Horizontal control for each sample location was determined by taping the radial distance to each location from each end of the baseline. The intersection of the radii determined the sample locations.

Skydrol™ Screening Level Analysis

APPENDIX D
SKYDROL™ SCREENING LEVELS

Skydrol™ (including its major constituents) is not listed on existing or proposed Federal and/or State drinking water standards developed under the Safe Drinking Water Act, or by the State Board of Health. In the absence of such standards, human health based concentrations were calculated for Skydrol's™ constituents using the formulas in WAC 173-340-720 that are protective of groundwater via direct ingestion of groundwater (i.e., groundwater cleanup level) and of soil with the potential to leach Skydrol's™ constituents to groundwater (i.e., soil screening level).

Calculating corrective action screening levels for Skydrol™ using MTCA formulas is complicated due to the lack of necessary toxicological information. The selected approach for developing screening levels for this study focused on tributyl phosphate (TBP), the primary constituent of Skydrol™. The available toxicity data for TBP includes a TD_{LO} (the lowest dose of a material introduced by any route, other than inhalation, over any given period of time and reported to produced any toxic effect). Using standard procedures outlined in EPA guidance (Ethier; EPA 1989) a TD_{LO} can be used to calculate a reference dose (RFD). Formulas provided in the MTCA Regulation can then be used to calculate human health-based cleanup levels.

The reported TD_{LO} for TBP is 12,600 mg/kg (Oishi 1982). This was administered to rats in feed at concentrations of 0.5 percent. Based on the amount of food a rat eats daily and an assumed rat weight, this corresponds to 500 mg/kg/day of TBP. Applying a safety factor of 10,000, consistent with EPA guidance, results in an estimated reference dose of 0.05 mg/kg/day. The reference dose can be used to calculate MTCA Method B human health-based concentrations of 4,000 mg/kg and 800 µg/L for soil (protective of direct contact) and groundwater, respectively. Multiplying the groundwater concentration by 100, as specified in WAC 173-340-740, results in a soil cleanup level protective of groundwater for TBP of 80 mg/kg.

The LD50 for Skydrol™ is 2,100 mg/kg and 3,000 mg/kg for TBP. This indicates that Skydrol™ is more toxic than TBP. Adjusting the TBP cleanup level downward based on the Skydrol™ LD50 results in a screening level for soil of 60 mg/kg (based on groundwater protection). As a further measure of conservatism, all four major constituents of Skydrol™ were summed, then compared to this screening level to determine if any individual soil sample was of potential concern.

The estimated groundwater screening level for Skydrol™, based on a revision of the 800 μg/L groundwater health-based concentration for TBP, is 600 μg/L. Again, all four major constituents of Skydrol™ were summed, then compared to this screening level as an added measure of conservatism.

REFERENCES

Ethier, Elizabeth. *The Role of Health-Based Criteria Development in UASTHAMA's Installation Restoration Program*. ORNL Publication 6489. Oak Ridge National Laboratory, Oak Ridge, TN.

Oishi, H., S. Oishi, and K. Hiraga. 1982. Toxicity of Several Phosphoric Acid Esters in Rats. *Toxicology Letters*, 13: 29-34.